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EARTH OBSERVATORY SATELLITE SYSTEM DEFINITION STUDY

REPORT NO. 2: INSTRUMENT CONSTRAINTS AND INTERFACE SPECIFICATIONS

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GRUMMAN

EARTH OBSERVATORY SATELLITE SYSTEM DEFINITION STUDY

REPORT NO. 2: INSTRUMENT CONSTRAINTS AND INTERFACE SPECIFICATIONS

Prepared For

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INTRODUCTION

1 - INTRODUCTION

The material in this volume is designed to aid NASA in its plan to begin acquisition of one or more of the instruments to be flown on the EOS spacecraft in support of the Land Resources Management (LRM) mission prior to selection of a prime contractor.

The material is grouped into two parts:

Part One - which contains program planning information and suggested acquisition activities

Part Two - which contains the following documents as Appendices:

1. A Performance and Interface Document applicable to both the Thematic Mapper (TM) and the High Resolution Pointing Imager (HRPI)
2. An Interface Control Document for interfacing the above instruments to the EOS Observatory
3. A Space Vehicle Integration Plan suggesting the steps and sequence of events required to affect the implementation of the above documents in a timely manner.
4. A group of suggested agreements between the Prime (Vehicle) and Associate (Instrument) contractors aimed at providing timely and equitable solution of problems at minimum cost to all concerned.

PROGRAM SCHEDULE
AND OPTIONS

2 - PROGRAM SCHEDULE AND OPTIONS

The procurement of the Instruments for the LRM mission of EOS-A should be initiated at the correct chronological time with respect to the overall program in order to take maximum advantage of the technology available and to minimize the non-recurring costs of integrating the Instruments into the spacecraft.

As a baseline for developing the procurement plan, the schedule in Table 2-1 is assumed.

Table 2-1 EOS Program Mission Schedule

MISSION	78	79	80	81	82	83	84	85	86	87
LRM										
EOS A, A' (185KM MSS, 330KM TM, DCS)		◆ A	◆ A'							
EOS B, B' (330KM TM, HRPI, DCS)				◇ →	◆ B					
					△ →	→	△ B' →	OPERATIONAL SYSTEM		
SEOS				▼A			△ B			
MARINE & WATER RESOURCES & POLLUTION										
EOS C (2-TM'S, HRPI, SAR)			▼ →	◆						
OCEAN DYNAMICS & SEA ICE										
SEASAT A	□									
EOS-D (SEASAT-B)				□						
WEATHER & CLIMATE										
EOS-E (TIROS-0)					□ →	OPERATIONAL SYSTEM				
SCIENCE										
SMM		□								

KEY:
◆ = COMBINED OPER/R&D MISSION
△ = OPERATIONAL LRM MISSION
▼ = R&D LRM MISSION
□ = NON-LRM MISSION

3-122(A)

PROCUREMENT SCHEDULE
AND OPTIONS

3 - PROCUREMENT SCHEDULE AND OPTIONS

The baseline procurement schedule for EOS is to be determined at the time of contract. Major (preliminary) baseline procurement milestones are listed in Table 2-2.

In general, the schedule calls for letting of the Instrument procurement contracts in June of 1975 to meet an initial launch date of June 1979. The critical design review would occur at the end of one year, June 1976, leaving three years to complete all fabrication, integration and qualification activities. This appears to be an adequate program span to allow a timely low risk development program for any of the instrument configurations currently defined.

Table 2-2 Major (Preliminary) Baseline Procurement Milestones

	74	75	76	77	78	79	80	81
Current Study								
Flight Schedule								
1st Launch								
2nd Launch								
3rd Launch								
Instrument Procurement								
Contract Award								
Prelimin. Design Review	TO BE DETERMINED							
Critical Design Review								
Demo Unit Integr. to Demo Veh. (qual)								
Qual Test Compl. on Demo								
Flight Article Accept.								
Flight Article Delivery								
ICD Updates (Milestone) (numbers)								

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RECOMMENDED PROCUREMENT PLAN

4 - RECOMMENDED PROCUREMENT PLAN

A number of programmatic and technical options must be evaluated prior to finalizing the procurement plan. The most important decision, upon which all others are thereafter founded, is that involving the earliest flight date for which a flight ready TM and/or a flight ready HRPI must be available.

The trade studies performed prior to the preparation of this document developed two significant points with regard to the TM and HRPI.

1. Each of the electromechanical scanner suppliers proposed a pair of instruments exhibiting a high degree of commonality
2. The Hughes and Honeywell designs for the baseline TM are physically and functionally interchangeable as far as the spacecraft is concerned, as are the two HRPI's from these suppliers.

Therefore, for a baseline TM or HRPI, acquisition from either source is acceptable without impacting the preferred vehicle configurations. The horizontally mounted Te Company design would require spacecraft design changes, but there appears to be no serious problem in accommodating Te's TM configuration. For a wide swath TM, the foregoing statement is still nearly true except for a weight growth in the Honeywell TM.

The great degree of commonality between the HRPI and TM from a given manufacturer implies that there is a considerable cost savings realizable from acquiring both instruments from the same supplier, possibly 20% of the cost of acquiring the instruments separately. There would also be a considerable savings in NASA management and prime contractor interface engineering costs. These cost savings would accrue even if the flight ready dates were as much as three years apart and would probably be optimum for flight ready dates about one year apart.

Therefore, it is recommended that serious consideration be given to soliciting bids for both instruments under a single contract with a staggered delivery date.

Grumman also concurs in the view that the instruments (and particularly the wideband tape recorder) for the EOS mission will require at least one year longer to acquire than will the spacecraft portion of the system. Therefore, it is recommended that ac-

Acquisition of the instruments prior to full system acquisition involves some cost risk unless steps are taken to keep the instrument design compatible with other mission and vehicle requirements. This risk can be alleviated through the following steps:

1. Division of the instrument acquisition program into two phases; (a) a definition and design phase and (b) a fabrication and test phase.
2. Implementation of an interim Interface Control Document on the program during phase (a) above, the design phase. Such an ICD is included in this volume.
3. Establishment of a System Integration Board at an early date to provide guidance and/or relief to the instrument supplier prior to the start of complete system design and integration.
4. Award of the system integration contract prior to the initiation of Phase B.

NASA/GRUMMAN/ASSOC.
INTERFACE

5 - NASA/GRUMMAN/ASSOC. INTERFACE MGT.

Beginning the acquisition of one or more instruments, which have a significant interface with the vehicle, prior to the start of vehicle acquisition works against a total procurement package approach to system acquisition. The dollar magnitude of the instrument acquisition program also suggests the probability of an associate contractor relationship between the instrument supplier, the vehicle supplier, and the system integrator if any.

Under such conditions, the problem of minimizing the program management costs can become difficult. Grumman has had excellent results, under similar conditions, on the F-14 aircraft program wherein the Hughes AWG-9 PHOENIX MISSILE SYSTEM was quite well along in development prior to final authorization of the airframe and assignment of this weapon system to the airframe.

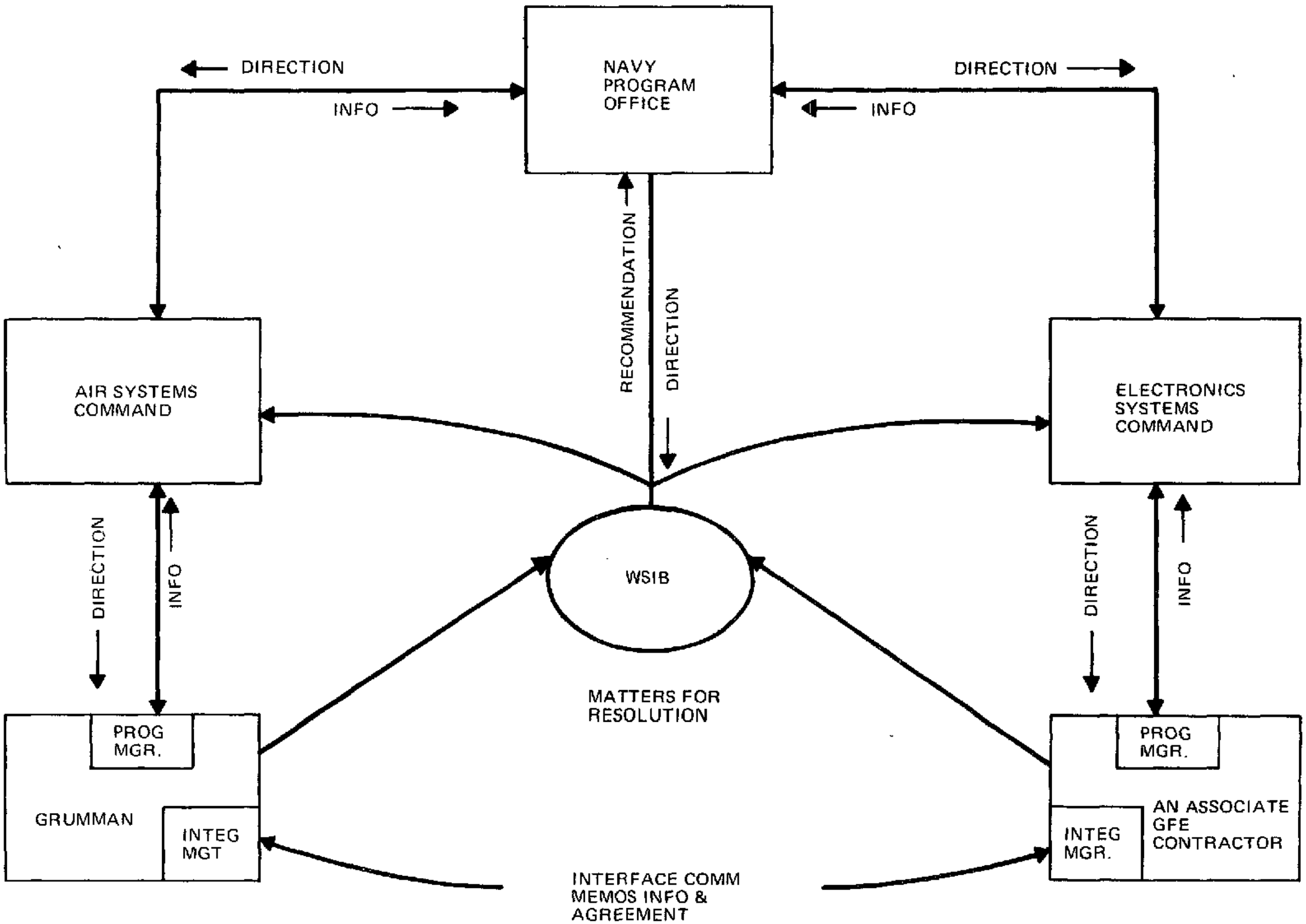
To minimize the program management costs, as well as certain overhead costs, the AWG-9 system was furnished to Grumman as GFE from an associate contractor. The mechanics of this relationship were as indicated in Figure 2-1. Each contractor had a separate contractual customer but one overall system/goal, a capable weapon system.

To achieve an overall system of high capability on a minimum cost schedule, the program manager at Grumman and at Hughes were given wide authority and provisions were made to minimize problems requiring resolution by the Navy. These provisions included:

1. Early imposition of an Interface Control Document
2. Early Development of a detailed Memorandum of Understanding and an Agreement of Responsibilities between the two contractors.
3. Maintenance of the ICD by the vehicle supplier.
4. Formation of a weapon System Integration Board to resolve minor matters with minimum time delay and to prepare a balanced presentation concerning any major problem, along with a joint recommendation for submission to the Navy.

These procedures provided an order of magnitude reduction in manhours involved in negotiations and in waiting for necessary go-aheads over the life of the program.

The key to this approach as it applies to this program is the System Integration Board. This board is constituted, by direction, of the minimum possible number of participants. The general concept calls for only one man from each contractor to be full time members. The chairman is from the vehicle/system integration contractors organization and the co-chairman is from the instrument contractors organization.



2-1

Fig. 2-1 System Integration Board Single Point Problem Resolution-USN

These two individuals are chosen to be outside the program related staffs of the particular contractor in order to avoid any emotional or preconceived biases when examining a problem. They are authorized to augment their staff as required from their present corporations staff and/or the program staffs as required on an Ad Hoc basis.

In the case of EOS, such a System Integration Board can be established between the spacecraft contractor and the instrument contractor(s) at an early date through a memorandum of Understanding even before full program go-ahead. In this case the spacecraft contractors support would logically be funded through a continuation of the system design studies and the instrument contractors support to the Board would be part of the normal program management cost allocation.

The system Integration Board in Figure 2-2 can be expanded to include other associate contractors as well during the life of the program; other instruments and/or the ground station contractor/operator.

The important thing is that the System Integration Board exist, that it function in resolving small matters and that it alerts all those concerned promptly of any major problems. Through the pathways illustrated, the Program Office is made aware of any problem simultaneously with the procuring activity. Conversely, direction can be given to all concerned concurrently and appropriate contractual and schedule adjustments can be worked in simultaneously by those affected. This can lead to significant program savings.

Under this concept each permanent member of the System Integration Board has a limited number of quite specific duties.

He and his counterpart in the Associate Contractor's organization act together as a System Integration Board which serves the NASA and the EOS Program by:

- o Seeking a mutually satisfactory solution to technical and programmatic differences arising in the course of performance.
- o Furnishing the joint recommendation of both contractors concerning any change proposed by either contractor which affects the total EOS system performance or interface.
- o Requesting direction when agreement on the proper course of action cannot be reached between the contractors.
- o Providing the contractors with the continuous visibility required to make effective day-to-day decisions.
- o Securing efficient utilization of expensive Government equipment through coordinated test programs.

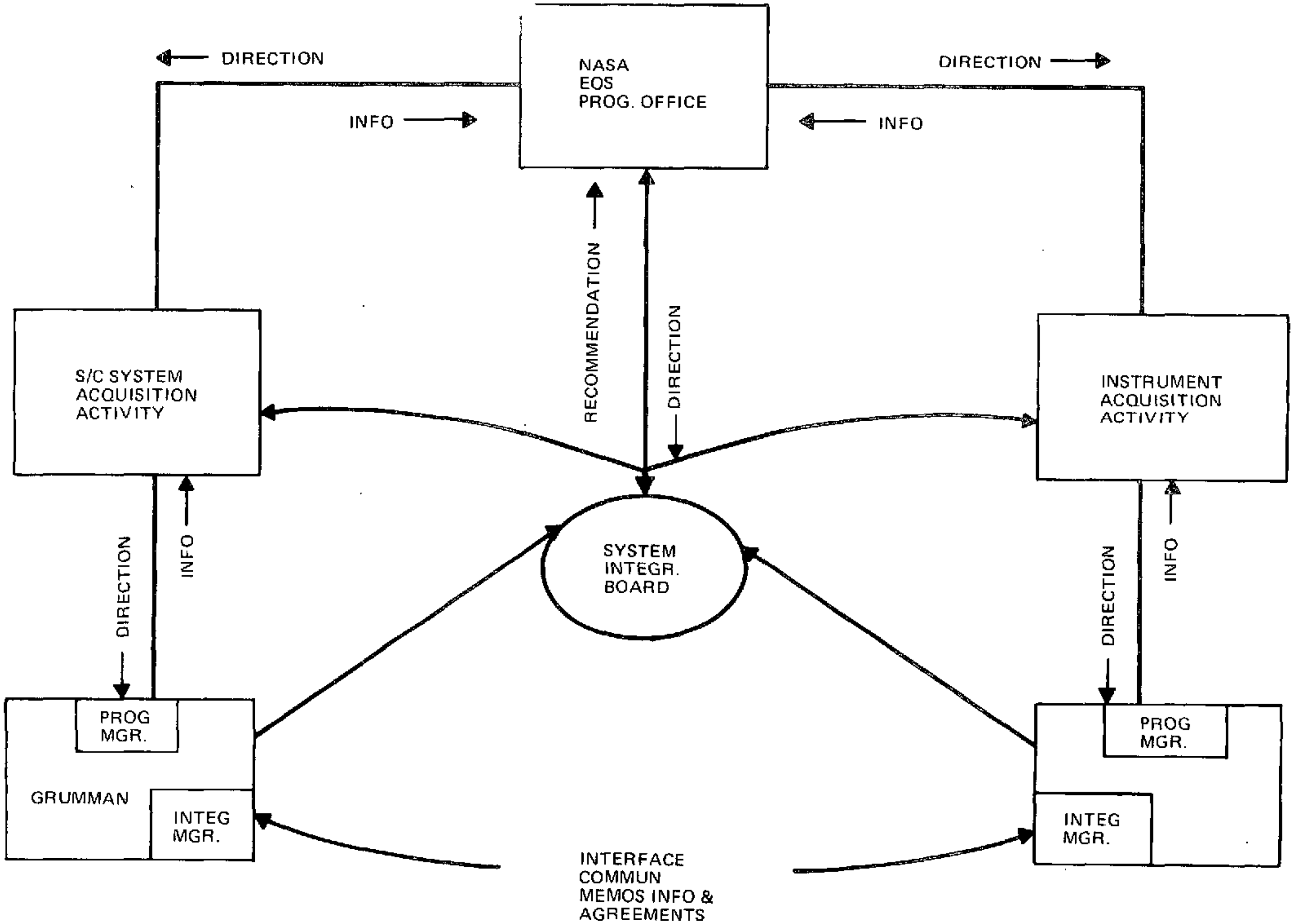


Fig. 2-2 System Integration Board Single Point Problem Resolution-NASA

Either SIB member has the right to initiate action or to obtain response, and each has an equal voice in reaching joint recommendations, decisions, initiating action, and the like. They must keep current on all such exchanges, and therefore control all interface correspondence flowing between Grumman and the Associate Contractor.

Following full program go-ahead, the System Integration Board would easily and logically become a staff group reporting to the overall System Integration Manager directly, receiving referred problems from him and responding with a coordinated recommendation initiated by all members of the board as representatives of their respective parent organizations.

5.1 INITIAL DOCUMENTATION

At the current time, it appears that the first EOS Observatory flights will carry a mix of operational and R&D instruments. The operational instrument which is assumed to be furnished GFE is:

An S-band Multi-Spectral Scanner (MSS) modified for flight at an altitude of 360 to 385 nautical miles and delivering 80 meter resolution (100 meter system performance).

The R&D instruments under consideration consist of two optical/IR sensors;

1. A seven band Thematic Mapper (TM) providing a 30 meter instrument resolution (40 meter system performance) over a swath of at least 185 Km located directly below the spacecraft. The unit is sensitive to four visual spectral bands, two near IR bands and one band at 10 microns.

2. A four band High Resolution Pointing Imager (HRPI) which is designed to provide a higher resolution of 10 meters (13 meters system performance) over a narrower swath width of 40 Km selectable out of a total swath of 786 Km located directly below the spacecraft. The four spectral bands are all in the visual region.

The recently completed trade studies have shown a number of possible options in the final design of the TM and HRPI which have not been adopted or deferred by the EOS Program Office. In addition, the Program Office is still exploring certain options related to overall system reliability and effecting the simultaneous coverage of the TM and the MSS. The Program Office is also analyzing several system configurations in an attempt to provide a more frequent revisit time within acceptable cost constraints.

In anticipation of the final configuration decisions, the following documents have been drawn up to reflect the most likely configuration:

1. An Instrument Performance Specification

2. An Instrument Interface Control Document.

quisition of the instruments be started as early as feasible in order to protect other program options which may evolve later.

The trade studies also showed that no overall system performance analysis of the instruments, data link and reconstruction equipment was available to define the quality to be expected of the radiometric data. Such a study must be performed before proceeding with further instrument definition.

5.1.1 INSTRUMENT PERFORMANCE SPECIFICATION

This document has been written as a composite document capable of being extended to cover all EOS missions by addition of subparagraphs in the performance sections of the two principle candidate instruments;

1. An extended capability advanced Thermatic Mapper (TM)

2. A physically similar High Resolution Pointing Imager. (HRPI)

The TM has been specified to cover a 330 kilometer swath width at 30 meters from a 680 kilometer orbital altitude. This extended swath width offers a much higher performance/cost trade for the instrument and the overall system than did the 185 kilometer swath.

Although the signal-to-noise ratio of a wide swath TM would be poorer than the Baseline 185-km design (assuming equal detector sensitivity), the user requirements of this program demand a considerably higher signal-to-noise ratio than that of the narrow swath design. Therefore, a specified signal-to-noise ratio four times higher than the point design has been specified for either swath width. This approach requires a two-dimensional sensor array to be located in the focal plane.

The TM as envisioned herein will deliver approximately 160 mega bits/sec of data and is expected to employ both quadrapture channels of a single transmitter during the A-A' mission.

The HRPI has been specified to cover a selectable 40 kilometers out of a total 786 kilometer swath from a 680 kilometer altitude. The nadir resolution is specified at 10 meters. The offset pointing is in steps of 1/3 of the total field of view throughout the total available angle ($\pm 30^{\circ}$).

The HRPI has been specified to maintain a constant sampling frequency even with changes in offset angle. The scan rate is programmable as a function of offset angle to minimize image overlap. The scan rate is as much as 25% higher at high offset angles.

Both sensors are to provide cooling to $200^{\circ}K$ for the detectors of band 1 to 4. Band 5, 6 and 7 of the TM are cooled further by a special passive cooler assembly.

The data interface is specified as digital for all instruments. This has been recommended by all of the suppliers. The question of serial or parallel data transfer has not yet been resolved. It should be left to the decision of the instrument and data processing contractor based on the state of the art at that time.

All of the instruments are expected to condition their analog telemetry prior to encoding by the standard TLM encoders adopted for the program.

5.1.2 ASSUMED THEMATIC MAPPER CONFIGURATION

The TM configuration specified in these documents operates at a nominal 680 Km altitude over a swath width of 330 Km providing a revisit time of 8-9 days. The unit provides a nominal 30 meter instantaneous field of view (IFOV) resulting in an overall system field of view (SFOV) of 36 meters. The actual IFOV of the instrument is specified separately for the along-scan and across-scan directions due to the differences in system implementation for the two directions (involving data sampling in the along-scan direction).

Furthermore, the sampling interval specified was chosen to allow the TM, with minimal on board data processing, to provide an accurate emulation of the operational MSS. This allows the TM to act as a true backup to the MSS as far as the many small data users are concerned and in fact prevents absolescence of any ERTS ground data processing equipment on later flights when the TM becomes the operational sensor.

This emulation capability would also be desirable in any canted sensor configuration where the TM and MSS scanned adjacent non-over-lapping swaths. By emulation, the ground user could receive an MSS type signal from either sensor.

The specified IFOV's are tabulated below to provide perspective:

	Along Scan	Across Scan
MSS Instrument	81M	81M
MSS Data Sampler	54M	–
MSS System Perf.	96M	81M

	Along Scan	Across Scan
TM Instrument	21M	27M
TM Data Sampler	27M	–
TM System Perf.	36M	27M
MSS Emulation by TM		
Sample Size	54M	81M
System Perf.	60M	81M

Thus, the TM when designed to include the emulation feature provides a data sample every 27 meters both along and across scan over the entire swath (38.5 microradians). This signal can be processed by summing to provide a 54 by 81 meter MSS emulation signal which is indistinguishable from the MSS.

The actual IFOV of the TM is adjusted to give an IFOV of 38.5 microradians in the cross scan direction and 30 microradians in the along scan direction. The lower IFOV in the along scan direction is needed to keep the system field of view less than 36 meters in the along scan direction. It is also of considerable value in improving the radiometric accuracy of the data since it is the along scan IFOV which is the principle parameter controlling the rise time and settling time of the data stream.

further reason to make the along scan IFOV small is due to the smear inherent in a scanner which does not employ image motion compensation to avoid image data smear during the sensor integration time. In the absence of IMC, the sensor cell must be made as short as possible to avoid introducing an additional MTF into the system design with a null at or near the desired system resolution.

Reducing the along scan IFOV will have some effect on the signal to noise ratio of the output. However, the values specified in the breadboard designs are already much too low to meet the radiometric performance needed by the Land Resources Mission. In general, a radiometric accuracy of not less than 5% is needed for each sample interval of the data if automated processing of the data is desired for relatively small fields and/or water features. This implies that two conditions must be met:

1. The sensor must be able to sense rapid geometric variations, limited by IMC, and achieve an output signal which is accurate to within 5% in the absence of noise.

2. The noise performance of the sensor must be such that at minimum acceptable input radiance levels, a signal to noise ratio sufficiently high to provide an expected signal level which is within ±5% of the true value. Such a SNR is approximately 10 for a high contrast scene and higher for low contrast scenes.

Because of the above considerations, it is recommended that the baseline TM employ a two dimensional sensor array and delay integration to raise the minimum SNR of paragraph 2.2.4.2 of the Performance Specification to at least 20 for the IFOV of 30 by 38.5 microradians.

5.1.3 ASSUMED HRPI CONFIGURATION

The same general comments apply to the HRPI as to the TM. The performance has been specified for a nominal 10 meter performance but in order to be harmonically related to the TM, the cross track ground IFOV is specified at 9 meters and the along track sampling interval has also been chosen to the 9 meters. The along scan IFOV of the instrument alone has been specified at 7 meters to give a system field of view of 12 meters along the scan.

To achieve radiometric data of adequate quality, the minimum signal to noise ratio of 20 has been specified at the minimum radiance high contrast condition. This specification also assumes the use of two dimensional sensor arrays and delay integration to achieve the required performance.

Momentum compensation is called for in the HRPI along with a rapid pointing capability. This combination will provide maximum sensor utilization without impacting the other instruments or the vehicle.

5.1.4 INSTRUMENT INTERFACE CONTROL DOCUMENT

This document is in very preliminary form since the choice of booster, specific spacecraft configuration, and sensor configuration has not been finalized. The document is however, complete enough to act as a working document during the early phase of flight instrument design. Many of the TBD's could be filled in as soon as a booster and sensor configuration is selected.

5.2 DOCUMENTATION AT SELECTION OF PRIME

Appendices D&E illustrate a series of understandings and agreements of responsibility used on the F-14 program to implement the System Integration Board concept developed above. These documents have provided a strong structure upon which a low cost approach to program management has been able to achieve an outstanding system in minimum time.

5.3 ADDITIONAL SPECIFICATION REQUIRED

During the preparation of the documents bound herein, certain areas were uncovered that require further technical definition to properly satisfy the applicable user requirements.

One of these areas involves the resolution expected of the system vis-a-vis the individual instruments. An additional analysis of the modulation transfer function of each of the optical and/or data processing functions in the data collection system should be performed - including whether they are determinate or statistical in nature - and an overall system response optimized by adjusting and/or re-optimizing each of the foregoing functional elements. This analysis would aid greatly in removing any possible ambiguity in the specification of the individual functions in the system.

An analysis similar to the foregoing should also be performed to determine the achievable radiometric accuracy of the system under various radiance and contrast conditions. Here again, both the determinate and/or statistical characteristics of each functional element should be defined to properly evaluate and optimize the overall system.

Following these two analyses, system performance can then be evaluated as a function of the resolution versus the radiometric performance, thereby gaining a considerably better matching of the designed system performance versus the detailed user requirements. This analysis will also aid in codifying users requirements into more precise terms.

APPENDIX A

APPENDIX A

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CONTRACT REQUIREMENTS	CONTRACT ITEM	MODEL	CONTRACT NO.

REPORT

NO. EOS-SS-300 DATE:

EOS

INSTRUMENT PERFORMANCE

SPECIFICATION DOCUMENT

CODE 26512

PREPARED BY: J. T. FULTON

TECHNICAL APPROVAL:

CHECKED BY:

APPROVED BY:

DEPARTMENT:

APPROVED BY:

SECTION:

APPROVED BY:

REVISIONS

DATE	REV. BY	REVISIONS & ADDED PAGES	REMARKS

GRUMMAN AEROSPACE CORPORATION

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1. SCOPE

This contract is for the design, fabrication and delivery of all components required to support the flight demonstration of a wide swath Thematic Mapper (TM) or a narrow swath High Resolution Pointing Imager (HRPI). The contractor shall accomplish all the necessary analyses, mathematical modeling, instrument design, fabrication and testing required to accomplish the tasks described in Section 2.0.

This specification establishes the requirements for a two phase program for: (a) the design, and (b) the fabrication and test of one (1) flight instrument. The necessary equipment required for the design, fabrication, test and flight operation of the instrument shall also be developed and fabricated under this program. The program equipment list is listed in Table 1.0.

This specification anticipates the start of this program to occur approximately one year before the start of the associated spacecraft program (EOS). Therefore, this document contains certain interface information and references a preliminary Interface Control Document (ICD), EOS-314-ICD-002, which will act as a guide to aid in the early design of the instrument. The Interface Control Document will become a contractual document after updating and prior to the start of instrument fabrication.

2. REQUIREMENTS

2.1 Functional

2.1.1 General

The TM (HRPI) shall collect, filter, and detect the radiation from the earth while it scans the earth scene below a satellite. Detectors utilized for this radiometer shall be state-of-the-art solid state devices with consideration to growth potential where appropriate. The electronics shall amplify and process the analog video signals prior to analog to digital conversion and present a parallel wire digital output at the interface for each spectral band sensed. Provisions shall be made in the radiometer system to supply test points and housekeeping telemetry signals in normalized form to a telemetry encoder installed within the volume of the instrument. Provision shall be made to accept binary and serial commands from a command decoder installed within the volume of the instrument.

The TM (HRPI) will be designated to operate in conjunction with a three axis stabilized Earth Observation Spacecraft launched into a near polar sun synchronous orbit of 680 Km nominal altitude.

The TM shall be designed to provide a continuous 320 kilometer wide strip map in each spectral band of the terrain directly beneath the spacecraft. The nominal nadir resolution shall be 30 meters.

The HRPI shall be designed to provide a continuous 40 kilometer wide strip map in each spectral band of the terrain directly beneath the spacecraft and on command at any angle up to ± 30 degrees from directly beneath the spacecraft. The HRPI shall be able to change offset angles, settle and begin transmission of useful data at a new offset angle within 20 seconds. The nominal nadir resolution shall be 10 meters.

2.1.1.1 Sun Angle

The minimum angle of the sun above the horizon shall be 30° at the minimum specified system performance.

2.1.1.2 Equatorial Crossing

Descending north to south at (TBD) A.M. local time nominal. (Between 9:30 & 11:30).

2.1.1.3 Sensor Ground Coverage

Perpendicular to the satellite ground track and 320 kilometers wide. (40 kilometers selectable out of a total 786 kilometers for the HRPI)

2.1.1.4 Offset Pointing

The HRPI shall be designed to offset point up to $\pm$ 30° from nadir upon command. The offset shall be adjustable in steps no larger than 1/3 the total field. Each step shall be repeatable to 0.10°. The offset angle at any time shall be provided to the wideband data and housekeeping TLM systems to six bits accuracy.

2.1.1.5 Sensor Sensitivity

Adequate to produce high quality signals in each spectral band from low reflectance scenes located in regions between 50° north and 50° south when the sun is at least 30° above the horizon. Nothing shall preclude the instrument from providing signals of lower quality in regions of lower sun angle.

2.1.2 (Reserved)

2.1.3 Radiation Detection and Signal Amplification

The radiation from the scene shall be focused by an optical system onto the detectors. Section 2.2.4 describes the optical characteristics of the detector portion of the radiometer. The signals from the detectors shall be amplified to the levels required by a digital signal processor. The amplifier shall have a linear output voltage versus input radiant energy transfer characteristic, plus other gain modes selectable by command.

2.1.4 Line Scan Accuracy

Scanning velocity and synchronization accuracy shall be such that lateral image displacement shall not exceed 15% of an IFOV element at any point along adjacent lines. This error shall not accumulate beyond an IFOV element over 10,000 consecutive scan lines. The above scan accuracies shall be either inherent in the scanning assembly or sensed with sufficient accuracy for proper correction during signal processing.

Scan modulation of the output signal at any point within scan line shall be less than 1%.

Overlap or underlap between adjacent lines shall not vary from the nominal design value by more than 10% of an IFOV element.

2.1.5 Video Signals

The video signals from the first six (Four for HRPI) spectral bands shall be capable of being registered with each other with an error of less than 10% of an IFOV element, and with the seventh band (if present), with an error of less than 10% of an IFOV element for that band. The signals obtained when the sensors of Bands 5, 6, and 7 are viewing the instrument housing, or a calibration flag, should appear as part of the video output of these bands and also added to the housekeeping telemetry. A voltage calibration signal shall be added to all channels. The video signal shall have no visible coherent or noncoherent noise (1/3 of peak-to-peak wide-band noise, as observed with a wavemeter).

2.1.6 Internal Radiometric Calibration

Means for establishing the radiometer calibration for all channels, internally, shall be defined early in the Design phase. The technique selected shall be adequate to meet the radiometric requirements of the TM/HRPI (better than ± 1% of full scale reading accuracy) and it shall use an internal radiant source and the sun as reference sources.

Two calibration targets shall be provided for the thermal band. If the instrument housing is used as a black body calibration source, its temperature shall be measured with appropriate sensors. These sensor

calibration signals, and any other temperature calibration signals, shall be provided both to the housekeeping telemetry and inserted into the video signals for each scan line.

The required accuracy for the thermal band calibration source shall be ±0.5° K at 240°K.

2.1.7 Radiometer Commands

The preliminary TM (HRPI) command list is given in appendix D of the Interface Control Document.

2.1.8 Timing Signals

A high frequency clock (about 100 megabits per second) shall be supplied to the instrument from the wideband data system. This clock shall be used for all internal timing functions and the clocking of the data outputs.

2.1.9 Power Source

The TM (HRPI) shall operate within specifications when supplied from an unregulated + 28 VDC power source.

2.1.10 Power Converter

A dc-to-dc power converter in the TM (HRPI) subsystem shall provide all voltages which may be required. The desirability of having the converter operate at frequencies which are integral multiples of and synchronized with the scan rate shall be studied. In case of failure of the synchronizing circuits, the converter shall continue to operate in a free running mode. If more than one dc-to-dc converter is required, they shall operate at frequencies which shall prevent the introduction of undesirable beat frequencies in the pass band of the radiometer. The concept of partial or complete redundancy of the power converters shall be defined during phase A.

2.1.11 Telemetry

The preliminary TM (HRPI) telemetry list is given in Appendix E of the Interface Control Document.

2.1.12 Test Points

Test points shall be provided for the TM (HRPI) subsystem to the extent necessary to determine the status of the instrument as well as metering points by which alignment of the instrument may be implemented. Short circuit protection of these points shall be provided. The instrument shall operate within specifications in the event of short circuit of the monitoring points and upon the removal of the short. All test points shall be brought out through a separate connector(s). The number of test points to be used shall be established and shall be approved by NASA prior to implementation.

2.1.13 Weight

The maximum weight of the entire instrument (optics, electronics, cooler, insulation, etc.) shall not exceed 160 kg (352 lbs).

2.1.14 Size, Shape, Center of Gravity, and Mounting

The physical parameters of the instrument shall be as specified in the Interface Control Document.

2.2.1 General

The anticipated electrical input signal and output signal parameters; the power requirements and the electrical performance characteristics of the radiometer are given in this section. All specified characteristics shall be within tolerance over the lifetime of the equipment despite the combined effects of signal, impedance, and power supply variations (within specified tolerances, but taken at worst case values), radiation degradation, and environmental extremes.

2.2.2 Input Signals

The presence of any, all, or none, of the input signals applied in any sequence shall not damage the equipment, reduce its life expectancy or cause any malfunction, either when the radiometer is powered or when it is not.

2.2.2.1 Timing Signal Input

The anticipated interfaces between the timing signal source and the radiometer are as follows:

T.B.D.

2.2.2.3 Power Subsystem

The power to the instrument will be unregulated +28 vdc (negative side grounded). Power ground bus to signal ground bus isolation, except at the common tie point external to the instrument, shall be provided in the instrument by the use of dc-dc converters or dc-ac inverters with the required input/output load characteristics. The basic power bus characteristics are given in Table 2 below:

TABLE 2 - BUS CHARACTERISTICS

Voltage	Unregulated, 28 volts nominal
Polarity	Negative ground
Transients	
Duration	120 milliseconds maximum
Rise & Fall Time	3 microseconds or greater
Amplitude	Bus Voltage drop to 20 volts or increase to 41 volts.
Ripple	500 mv pk/pk maximum

The power consumption of the instrument shall be kept to a minimum consistent with reliable operation to specifications. The required power shall be closely estimated during Design, at which time a power profile shall be generated and updated as design and test progress.

2.2.2.4 Line Synchronization Signals

The instrument shall generate line synchronization signals of suitable accuracy to process the video signals on the ground so that along and crosstrack errors are within the requirements stated in paragraph 2.1.4 and 2.4. The nature and number of line synchronization signals is given in the Interface Control Document.

2.2.2.5 Telemetry Power

A separate + 28 volt line will be provided for housekeeping telemetry circuits.

2.2.3 Output Signals

2.2.3.1 General

The data from each spectral band of the instrument shall be brought out and interfaced with the wideband data system in parallel digital fashion. The line synchronization signals will also be routed to the wideband data system in digital form. All lines to the data system will be on separate buffer isolated lines. The signal timing plan is specified in section 5.4.4 of the Interface Control Document. Short circuit protection of all outputs shall be provided. The radiometer shall operate within specification, except for the shorted output while the output is shorted, and the entire radiometer shall operate within specification after removal of a temporary short.

2.2.3.2 Video Signal Outputs

Separate video signal outputs shall be generated for each band. Each video signal shall include the radiometer signal while scanning the earth scene, solar calibration target, and a suitable internal calibration target(s).

The format of each signal shall be in accordance with section 5.4.4 of the Interface Control Document.

A voltage calibration signal shall be added to the video signal train in each channel during a portion of each scan at the input of the

detector preamplifier. In addition, any parameter which can change the on-orbit calibration by 0.5% or more shall be included either in the video signal train, or telemetered to the ground, to facilitate data processing. ing.

2.2.3.3 Sync Pulse Signal Output

The scan line to scan line jitter, including noise, of the synchronization pulse shall be equivalent to less than 4×10^{-3} milliradians. The jitter of the synchronization pulse between any two scan lines within a 20-minute period shall be within 40×10^{-3} milliradians.

2.2.3.4 Electronic Reticles

The instrument shall be able to provide to the signal processor electronic reticle signals. The method for their generation, their characteristics and number, are as defined in section 5.4.4 of the ICD.

2.2.3.4.2 Control Lines to Processor

The instrument shall provide, as a minimum, the following signal lines to the data processor. These lines, and the instrument, shall not be damaged by a short to the power bus or ground.

1. Start of Scan or Phasing Pulse
2. End of Scan Pulse
3. Mid-Scan Pulse (Commandable)
4. Electronic Reticles (commandable)
5. Data Lines for all Channels.
6. Scan error of detector #1.

Additional control signals to the processor shall be defined during Phase a as required to reconstruct the instrument/images on the ground to this performance specification.

2.2.3.4.3 Interface Characteristics

The signals between the instrument and the data processor shall have line driver outputs. Their electrical characteristics will be defined during Phase I for amplitude, load current, source capacitance. In

addition, consideration must be taken for coaxial cable impedance between the two units.

2.2.3.5 Telemetry Outputs

Enough telemetry points shall be designed for evaluation of the status and performance and to troubleshoot the radiometer in the event of difficulties. It shall be possible to obtain telemetry regarding all radiometer temperatures whether the radiometer electronics is ON or OFF. It shall be possible to short any telemetry output to the power bus, or to ground, or to other telemetry outputs without damaging the telemetry circuitry or affecting in any manner whatsoever the performance of the radiometer.

Digital telemetry shall have the following characteristics:

Amplitude	-0.6 V	"0"	0.7 V
	3.5 V	"1"	5.2 V

Capacitance 500 pf max

Under failure conditions in the radiometer, the digital functions shall not exceed +25 volts or -0.8 volts. If any type of failure in the radiometer could cause the digital input to exceed these limits, then protective clamping shall be provided.

2.2.3.5.2 Housekeeping Telemetry

Analog telemetry shall vary between +0.2 and +5.0 volts to be converted by the telemetry processing system (which is not part of the radiometer) to an eight bit word.

The output impedance shall not exceed 10K ohms. Capacitor terminated outputs shall be provided with appropriate bleed-off paths.

Under failure conditions in the radiometer, the analog functions shall not exceed +25 or -0.8 volts. If any type failure in the radiometer could cause the analog inputs to exceed these limits, then protective clamping shall be provided.

The housekeeping telemetry shall include, but not be limited to:

1. First stage cooler temperature
2. Second stage cooler temperature
3. Several of radiometer housing temperature sensors
4. Scan Drive Current
5. Band 5 detector bias
6. Band 6 detector bias
7. Band 7 detector bias
8. Scan position
9. Heater power in cooler

The operating range of these parameters shall fill the entire scale of the telemetry to insure maximum resolution.

2.2.3.6 Test Points

2.2.3.6.1. Description

Test points shall be provided for the instrument to the extent necessary to determine the status of the radiometer as well as metering points by which alignment of the instrument may be implemented.

The test points may be utilized during testing. Short circuit protection of these points shall be provided. The instrument shall operate within specifications in the event any test point is shorted to power bus, ground, or another test point, and upon removal of the short. All test points shall be provided through a separate keyed connector(s). The final list of test points shall be defined during Design and shall require approval of NASA.

2.2.3.6.2 Test Point Locations

As a minimum, the location of test points shall be as follows:

1. Band 1 video signals
2. Band 2 video signals
3. Band 3 video signals
4. Band 4 video signals
5. Band 5 video signals

6. Band 6 video signals
7. Band 7 video signals
8. Temperature calibration signals
9. Sync pulse signal after phasing with 1.0 MHz clock
10. Mid-Scan Pulse
11. Externally introduced signal to cause DC restoration to both visible and IR bands.
12. Voltage calibration signal

The final list of test points shall be established during Design

2.2.4 Sensitivity

This subsection is divided into two distinct parts, TM sensitivity and HRPI sensitivity.

2.2.4.1 General, TM

The analysis and design of the systems which process the signals shall consider the basic photon limited quality of the signals and preserve to the greatest extent possible the radiometric and image qualities as limited by the radiation background from the scene and intervening atmosphere. An analysis shall be conducted to determine signal quality for Band 7 under conditions of various times of day including the dark side of the orbit.

2.2.4.2 Bands 1 through 6 Sensitivity, TM

Bands 1 through 6 shall produce a minimum low spatial frequency signal-to-noise ratio (SNR), defined as peak-to-peak signal voltage to RMS noise voltage, in accordance with the following table:

Spectral Band (Micrometers)	Minimum Input Radiance ($X 10^{-5}$ watts/cm^2-Ster)	SNR Minimum
1. 0.5 - 0.6	22	20
2. 0.6 - 0.7	19	20
3. 0.7 - 0.8	16	20
4. 0.8 - 1.1	30	20
5. 1.55 - 1.75	8	20
6. 2.1 - 2.35	3	20

These performance values shall be demonstrated analytically during Design and experimentally during test using high contrast low spatial frequency targets.

2.2.4.3 Band 7 Sensitivity, TM

The sensitivity of Band 7 is measured in terms of the Noise Equivalent Temperature Difference (NETD) at two specific temperatures 220°K and 300°K. The NETD is defined for purposes of this specification as the change in scene temperature about a given temperature which will cause a change in signal peak-to-peak amplitude equal to the RMS noise. The maximum NETD for this band for an extended scene of 200°K and 300°K shall be 0.5°K.

Spectral Band (Micrometers)	Minimum Input Radiance ($\times 10^{-5}$ watts/cm^2-Ster)
7. 10.4 - 12.6	200
	(300°K) (Nominal) (NETD @ 300°K = 0.5°K)

2.2.4.4 General, HRPI

The analysis and design of the systems which process the signals shall consider the basic photon limited quality of the signals and preserve to the greatest extent possible the radiometric and image qualities as limited by the radiation background from the scene and intervening atmosphere.

2.2.4.5 Bands 1 through 4 Sensitivity, HRPI

Bands 1 through 4 shall produce a minimum low spatial frequency signal to noise ratio (SNR), defined as peak to peak signal voltage to RMS noise voltage, in accordance with the following table:

Spectral Band (Micrometers)	Minimum Input Radiance ($\times 10^{-5}$ watts/cm^2-Ster)	SNR Minimum
1. 0.5 - 0.6	22	20
2. 0.6 - 0.7	19	20
3. 0.7 - 0.8	16	20
4. 0.8 - 1.1	30	20

These performance values shall be demonstrated analytically during Design and experimentally during test using high contrast low spatial frequency targets.

2.2.5 Dynamic Range

2.2.5.1 General

The dynamic range of bands 1 through 6 shall be adjustable to meet the requirements of paragraph 2.2.3.2. This gain adjustment shall be made only one time and shall be accomplished by a fixed resistor.

2.2.5.2 Dynamic Range Bands 1 through 6

Bands 1 through 6 shall be capable of providing calibrated radiance measurements of solar radiation reflected from a scene with a brightness variation of from 0.5 percent albedo to an adjustable upper limit of eighty percent albedo outside the atmosphere, in areas between 50° north and 50° south latitude. The actual radiance values defining the expected dynamic ranges will be a function of the reflectance of the brightest earth targets of interest and of the spectral band in which they are observed, and it shall be compatible with the sensitivity values given in paragraph 2.2.4.2 and 2.2.4.5 for a 3% target reflectance. It is anticipated that under certain conditions, a large, within the scene, dynamic range may be difficult to accommodate with a linear gain amplifier without sacrificing signal-to-noise in the low reflectance targets of the scene.

2.2.5.3 Dynamic Range Band 7

Band 7 shall be capable of providing calibrated radiance measurements of scenes having temperatures of from noise level to 320°K, with sensitivity values compatible with those given in paragraph 2.2.4.3. The need for different modes of amplification for this band shall be established during Phase a.

2.2.6 Spatial Resolution

The instantaneous field of view of each instrument shall be as defined in 2.4.4 and as tabulated below for a nominal altitude of 700 KM:

	Visible Bands Bands 1-6 or 1-4		IR Bands	
	Along Scan	Across Scan	Along Scan	Across Scan
TM	21 Meters	27 Meters	63 Meters	81 Meters
HRPI	7	9	-	-

2.2.6.1 Effective Instantaneous Field of View (EIFOV)

The EIFOV is defined as the resolution of the 50% point on the modulation transfer function (MTF). The modulation transfer function (MTF) shall be measured through the spatial frequency range of the instrument for each of the seven bands out to the first null. In the very low frequency reference region several points shall be measured to assure that the dc level has been established. The required instrument MTF shall be measured for performance compliance in directions which correspond to the horizontal and vertical scans (along and cross-track directions).

2.2.6.2 Bands 1 through 6, TM

The spatial resolution of bands 1 through 6 shall be adequate to provide peak to peak modulation transfer of at least 0.5 for simulated subsatellite target sizes along the scan corresponding to 30 microradians per half cycle of spatial frequency. The target contrast ratio shall be 30:1 or higher.

2.2.6.3 Band 7, TM

The spatial resolution of band 7 shall be adequate to provide peak to peak modulation transfer of at least 0.5 for simulated subsatellite target size corresponding to 120 microradians per half cycle of spatial frequency. The target contrast ratio shall be 30:1 or higher.

2.2.6.4 Band 1 through 4, HRPI

The spatial resolution of bands 1 through 4 shall be adequate to provide peak to peak modulation transfer of at least 0.5 for simulated subsatellite target sizes along the scan corresponding to 10 microradians per half cycle of spatial frequency. The target contrast ratio shall be 30:1 or higher.

2.2.7 Grounds

The grounding philosophy used for the instrument design shall adhere to the policy defined in the following paragraphs. Any deviations shall be justified and require prior NASA approval. A complete grounding analysis and diagram shall be generated during Design and shall form the basis for the design of the instrument.

2.2.7.1 Case Ground

The case ground shall be DC isolated from all other grounds. A connector pin (preferably Pin #1) shall be provided for the case ground.

2.2.7.2 Shield Grounds

Shield grounds shall be provided for all input and output signals except for:

1. DC power inputs and outputs
2. Telemetry Signals

All the input shield grounds on each unit shall be connected to a common shield return within the unit which shall be DC isolated from all other grounds. A separate pin on each connector shall be provided for the common shield return.

All the output shield grounds on each unit shall be connected to a common shield return within the unit which shall be DC isolated from all other grounds. A separate pin on each connector shall be provided for the common shield return.

Shield returns for redundant assemblies shall be isolated from each other.

2.2.7.3 Input Signal Returns

Input signal returns, other than for test points, shall be isolated from each other and from the power return.

2.2.7.4 Output Signal Returns

Output signal returns, other than for test points or telemetry points, shall not share a common lead return path, but shall be returned through separate leads on separate connector pins.

2.2.7.5 Power Returns

Power returns for redundant assemblies shall be isolated from each other. The design shall be such that a failure in one of the redundant units shall not open the power return to the other unit.

2.2.8 (Reserved)

2.3 Mechanical

There are four major elements in the design of the instrument: (1) the telescope, including the optics and structual interface between the instrument and the spacecraft; (2) scan mechanism; (3) the spectrometer; and for the TM only, (4) the radiant cooler.

2.3.1 Mounting

The method for mounting the instrument shall be as defined in section 5.3.1 of the ICD.

2.3.2 Scanner Drive

The instrument drive shall meet, as a minimum, the following requirements:

1. The scanning system shall have a scanning rate that insures continuity of adjacent scans at the subsatellite point for the high resolution bands (1 through 6). The scan rate shall be synchronized with the timing signal clock. The scan velocity variation in any one scan line shall be adequate to meet the requirements of paragraph 2.4.4.3 and 2.4.4.3.1. Consideration will be given to achieving this linearity by means of correcting timing signals optically derived. These signals

shall be transmitted with the image data. The scanning rate shall produce no scan overlap or underlap of contiguous scan lines of greater than 10% of an IFOV.

2. The design shall assume 24 months operation in an orbital type environment.

3. Uncompensated Momentum - the uncompensated momentum shall be less than 0.3 inch-pound-seconds RMS, and 0.35 inch-pound-seconds peak value. Adherence to this requirement shall be demonstrated by measurement or computation. Any variation must require approval by the Technical Officer.

4. If a closed loop velocity or position servo system is employed, the phase margin shall be at least 35 degrees.

5. Lubrication - the mechanisms which require lubrication shall be given special consideration in their design. Rotating and translating mechanisms shall be driven with torque/force margins at least 6db greater than required for the function. This will assume a range of operating temperature and continued degradation due to wear and lubricant evaporation or build-up. In addition, an overvoltage capability for overdriving the scan mechanism shall be designed and built into the system. The lubricants rate of evaporation must be considered both from the standpoint of increased loads and contamination of optics. A definitive lubrication system must be presented at the end of Design with verification at the component level of its adequacy. The final choice of lubricants must be approved by NASA.

2.3.3 Scanner Alignment

A method shall be provided for measurement of the alignment of the radiometer's optical axis with respect to two external reference surfaces on the radiometer frame. Provisions shall be made to precisely attach alignment mirrors and witness mirrors for contamination measurements either permanently or when required to these surfaces.

The alignment mirrors in turn may be used to boresight the radiometer to a mounting fixture and must be located in a convenient position

for this purpose. The measurement of the optical axis alignment with the mirrors shall have an accuracy of ± 0.1 milliradians. Alignment of the axes of the seven bands shall not change more than 0.1 milliradians as a result of all testing.

2.3.4 Offset Pointing

An offset pointing capability shall be designed for the HRPI so that while scanning, on command, the FOV of the instrument can be rotated about the velocity vector up to $\pm 30^{\circ}$ from its nominal or zero position.

The selectable rotation positions shall be in nominally $1/3^{\circ}$ of the field of view. A method shall be designed such that, after the slew mirror has been rotated, the precise angular position is known to within 0.01°. This signal will then be telemetered. The offset pointing approach to be designed shall have a fail-safe mode of operation, that is, the system must always return to its zero position in case of failure of its drive system.

The HRPI shall be aligned so that the nadir appears in the center of its overall scan capability and also in the center of its scan when pointed at the nadir.

2.3.4.1 HRPI Scan Angle

The HRPI shall be capable of scanning any 57 milliradian (40 KM @ a nominal 700 KM orbit altitude) swath out of a total swath of $\pm 30^{\circ}$.

2.3.4.2 HRPI Offset Angle

The instrument shall be commandable in 1.0 degree steps throughout the total $\pm 30^{\circ}$ offset capability.

2.3.4.3 HRPI Offset Time

The instrument shall be capable of unlatching, moving and relatching in a new position at a rate of 5 degrees in 20 seconds.

2.3.4.4 Vibration and Momentum Transfer

The instrument shall settle in its new position within 10 seconds after an offset angle change, residual vibration amplitude less than ± 2 microradians RMS.

The uncompensated momentum transferred to the spacecraft during and following any offset angle changes shall be less than TBD.

2.4 Optics

2.4.1 General Requirements (TBD)

2.4.2 Spectral Response

The total spectral response shall be specified for each band and shall include the optics and the detectors. This response shall be obtained by measurement of both the optical spectral bands and the spectral response of the detectors within and outside the band in which they are going to be used.

2.4.2.1 Filter Characteristics

The spectral filter used to define the seven bands shall have the characteristics shown in Table 3.

2.4.3 Detectors

2.4.3.1 General

The type and number of detectors used in each band of the instrument shall be adequate to meet the minimum performance requirements stated in this specification.

2.4.3.2 Bands 1, 2, 3 and 4

The present state of the art in cooled preamplifiers and cooled solid state detectors shall be used to satisfy the performance requirements.

2.4.3.3 Bands 5, 6, and 7

Radiant energy detectors operating in the 1.5 to 2.5 and 10 to 13 micrometer region shall be used for these bands. The detector arrays

TABLE 3

FILTER CHARACTERISTICS

Band Number	1	2	3	4	5	6	7
Filter Type	Bandpass	Bandpass	Bandpass	Bandpass	Bandpass	Bandpass	Bandpass
Cut-On Wavelength (μM)	0.5±0.01	0.6±.01	0.7±.01	0.8±.01	1.55±.01	2.08±.01	10.4±.01
Cut-Off Wavelength (μM)	0.6±0.01	0.7±.01	0.8±.01	1.1±.01	1.75±.01	2.35±.01	12.6±.01
Edge Slope(1) (μM)							
Short Wave Side	.02	.02	.02	.02	.02	.02	.02
Long Wave Side	.04	.045	.05	N/A	.04	.04	.04
Efficiency (Minimum)	.9	.9	.9	.9	.9	.9	.9
Spectral Flatness(2) (percent)	75	75	75	75	75	75	75
Spurious Transmittance (3) (percent)	5	5	5	5	5	5	5

NOTES:

(1) Edge slope is defined as the wavelength interval between 5% absolute transmittance and 70% of peak transmittance. The above are maximum values.

(2) Spectral flatness is defined as the percent of the wavelength range (bandwidth) over which the transmittance does not vary by more than 5% of the peak transmittance.

(3) Spurious transmittance is the ratio of the integrated solar energy transmitted outside the bandpass to that within the bandpass. This requirement may be waived where it can be shown that the detector response outside the bandpass is less than 5 percent of the total integrated energy within the bandpass.

for bands 5 and 6 shall require minimum cooling to minimize the load on a radiant cooler. The energy impinging on the detectors for these three bands shall arrive in a collimated bundle to minimize the effects of relative motion between the radiant cooler assembly and the rest of the optical system.

2.4.4 Instantaneous Field of View

The instantaneous field of view (IFOV) shall be defined as the solid angle bound by the points where the detector voltage response to a point source is 50% of the maximum obtained when the source is located on the axis defined by the telescope assembly. The voltage response to this same point source shall be 1% or less at angular distances equal to or greater than two (2) instantaneous fields ov view. Measurement of all instantaneous fields of view shall be made with the scanning system drive disabled and scan mechanism locked in a fixed posibion relative to the housing reference surfaces. The instantaneous field of view shall be some geometric shape defined by the appropriate number of microradians on each side of a rectangle. These measurements shall be accurate to within 4 microradians.

2.4.4.1 Registration of Elemental Fields of View

Points imaged simultaneously in separate bands shall be registered to within an integral number of IFOV's to an accuracy of ±10% of an IFOV along and crosstrack for the whole instrument. This includes all synchronizing and correcting signals originating from the instrument that are required to process the data into an image, considering degradations such as those caused by a typical transmitting/receiving/signal processing system.

2.4.4.2 Scanned Field of View

The scanned field of view is the solid angle resulting from motion of the elemental field of view by the scanning mechanism. The angle

between the center of the elemental field of view in the center and two extremes of that rotational angle required to cover 320 kilometers on the ground, and a plane normal to the optical axis shall be identical within ±4 microradians. Scanning angles are measured in the direction of scan from the zenith direction. The orientation of the radiometer is as it would be if mounted on a spacecraft.

2.4.4.3 Scan Linearity and Stability

The modulation of the output signal produced by the scanner shall not vary more than 1% of full scale from swath center to edge when the optical input to the scanner is equivalent to that produced by a uniform flat field from object space.

2.4.4.3.1 Scan Linearity

The scan shall traverse a flat surface at a distance of 680 KM from the instrument and perpendicular to the instrument line of sight in such a manner so that no pixel in the resulting output data stream is more than 20 pixels removed from its true geometric position.

If data is taken on both the forward and reverse scan of an oscillating scanner, no adjacent pixels in the object plane shall be displaced from their neighbor by more than 5 pixel intervals from their theoretical position in the output data stream.

2.4.4.3.2 Scan Stability

Critical parameters of the scan mechanism such as flatness, scan linearity, jitter, and scan repeatability as a function of age and temperature, shall be analyzed and tested at the component and system level.

2.4.4.3.3 Scan Line Synchronization

A scan line synchronization reference shall be provided with each line of video in each spectral band. The design of the sync system shall assure that the final image is maintained in line to line alignment to better than an equivalent of 3.5 meters. If the scan across the swath is not linear to 0.1%, scan rate information shall be provided and shall be adequate to correct the ground processing system to

generate images of better than 0.01% (18 meters) geometric aspect and ground point location. The scan shall be capable of generating a number of electronic reticle marks per line, optically generated, to be used for scan linearity assessment and correction.

2.4.5 Tolerance Sensitivity Analysis

A complete tolerance and tolerance sensitivity analysis shall be performed on the instrument optic system. This analysis shall be updated and verified during the detailed design and test phases of the overall program. As one of the results of this analysis, the focus sensitivity of the instrument shall be determined and, if necessary, a recommendation made for the best technique for re-focusing the instrument during environmental tests and in-orbit. After approval by NASA, the re-focusing system shall become part of the instrument design. The main objective of the tolerance and tolerance sensitivity is to verify the adequacy of the design and ascertain the instrument will maintain performance within specification in the environment it is expected to operate and during its life. Accordingly, the tolerance analysis shall address, as a minimum, the following categories:

1. Alignment and Fabrication
2. Environmental (Thermal and Vibration)
3. Operational (Dynamic)
4. Effect of 1 g force on Telescope

2.4.6 Internal Self-Calibration

Calibrating references of all bands shall be incorporated into the optical system to provide internal radiometric self-calibration of the instrument to an accuracy of better than 2%. Internal radiant sources and/or the sun may be used for this purpose. These calibration references shall either be rendered as calibration data for computer purposes or used to correct output data before photographic recording to provide uniform pictures.

2.4.7 Radiation Input Range

Above the normal range of radiation into the radiometer, under certain conditions, the radiometer may scan through the sun on several

successive scans. The instrument shall be protected internally against direct solar input. The radiometer shall return to its calibrated condition within 10 seconds after exposure to the sun.

2.4.8 Suppression of Stray Radiation

Suitable optical baffles shall be used in the telescope to reduce the effect of stray radiation on the performance of the radiometer. The measurement of a minimum brightness target element in any channel shall be changed by less than 2% of full scale by the presence of a maximum albedo scene extending from 3 to 30 or more elemental fields of view in all directions.

2.4.9 Sun Shield

Sun shields may be used on the radiometer if the contractor requires them to supplement the internal optical baffles in suppressing unwanted radiation. If sun shields are used they shall be limited to the same envelope constraints as the radiometer. The sun shields are to be mounted as part of the radiometer.

2.5 Environmental

2.5.1 Thermal

The thermal design shall be based upon rejecting all heat to space. Vehicle interfaces shall not be used as heat sources or heat sinks.

A thermal analysis of the instrument shall be conducted using a thermal model. This model shall be in sufficient detail to evaluate component temperatures and thermal gradients on a steady state and transient basis. This analysis shall include the degrading effects on image quality. The thermal model shall be documented in detail, showing all thermal inputs, and all assumptions. The detail and status of the model and analysis shall be consistent with the status of the program, and updated accordingly.

2.5.2 Detector Cooling

When detector cooling is required, the thermal design shall use passive techniques. The location of a passive cooler shall be optimized for the specified orbit parameters, to achieve a minimum size and weight

for the required operating temperature. The design of a shielding system shall take into account all environmental heat inputs (direct solar, earth albedo, and earth radiation) as well as all heat inputs of the vehicle. A thermal analysis shall be conducted, using a detailed thermal nodal model to achieve a cooler design and evaluate cooler performance. A sensitivity analysis shall be performed using the thermal nodal model. This analysis shall consider the individual and combined effects of all parameters which impact cooler performance. Justification for tolerances on all parameters shall be specified. The cooler thermal model and analysis shall be documented in detail showing all thermal properties, all thermal couplings, all heat inputs, and all assumptions. The detail and status of the model and analysis shall be consistent with the status of the program, and updated accordingly.

2.6 Miscellaneous (Reserved)

2.7 Product Assurance Requirements

2.7.1 Scope

The contractor's existing quality assurance program shall be utilized in assuring adequate workmanship is maintained. A brief description of the contractor's quality system shall be included in the proposal.

During Design, the contractor shall establish an informal system for reporting malfunctions and corrective actions taken to NASA. It is the intent of this informal malfunction reporting system to prevent the overlooking of failures due to shortcomings of equipment design, as opposed to those due to relaxation in requirements to use screened hi-rel parts or to the use of non-standard materials and manufacturing techniques which may be approved by NASA in order to reduce costs.

2.8 Drawings

All engineering drawings and schematics shall conform to the contractor's established set of practices for preparation, dimensioning and tolerances. A mutually agreed upon system to ensure change control of all documents effecting hardware and software shall be implemented after the

3. TEST REQUIREMENTS

As a minimum, the following tests shall be performed to demonstrate instrument compliance to this specification:

1. Suppression of stray radiation
2. Optics Alignment
3. Spectral bandwidth
4. Focus
5. Field-of-view horizontal and vertical and alignment of scan plane with respect to scanner coordinate system.
6. Amplifier gain
7. Video bandwidth
8. Dynamic range
9. Signal-to-noise ratio as a function of radiance input
10. Synchronization pulses jitter and width
11. Spatial resolution (cross and along track directions)
12. Scan linearity, jitter, and scan function waveform
13. Sensitivity and radiance calibration
14. On board calibration test
15. Pictorial Displays (if any)
16. Band to band registration
17. Optical aberrations and image spread functions
18. Internal calibration accuracy and stability
19. Overlay and underlap

3.1 Spectral Bandwidth

The relative spectral bandwidth of each band shall be measured on the radiometer's entire optical train. A monochromator may be used as the variable wavelength source. The relative spectral response data may be referenced to the spectral response of a calibrated thermocouple detector. The wavelength regions which will be scanned are as follows:

Bands 1 through 4 - 0.2 to 2.4 micrometers
Bands 5 through 7 - 0.7 to 18 micrometers

Beyond the 1% relative response points of each band, the maximum spectral bandwidth of the monochrometer (if used) shall be used to measure the out of band response of the radiometer.

3.2 Modulation Transfer Function

The signals modulation as a function of spatial resolution shall be measured in the scan direction and crosstrack direction by means of appropriate spatial resolution targets.

3.3 Radiance Calibration

All seven bands (4 on HRPI) may be calibrated at ambient pressure. At a minimum, the radiance calibration shall be performed twice: once before tests and once after all other tests have been completed.

3.4 Detector Stability

Tests shall be conducted or data presented, if available, to demonstrate that the sensitivity stability as a function of time of the selected detectors is sufficient to insure that the performance requirements of all seven bands can be met throughout the instrument life time.

3.5 Self Testing

The radiometer shall include provisions for self testing by means of test points and radiance calibration. Calibration of internal temperature sensors shall be accurate within 0.2° at +28 volt supply voltage except where noted otherwise.

3.6 Environmental Testing

The radiometer shall be designed to survive when subjected to various types and degrees of environmental tests. The unit shall be designed to be operated during these tests in a manner simulating actual operation during launch/orbit, and to meet all specified operational performance criteria during these tests except that for vibration and acceleration only survivability with no degradation is required.

The Interface Control Document specifies the required levels.

APPENDIX B

APPENDIX B

CONTRACT REQUIREMENTS	CONTRACT ITEM	MODEL	CONTRACT NO.

REPORT

NO. -314-ICD-002 EOS-113-IC-001 DATE: 15 July 74

INSTRUMENT INTERFACE CONTROL DOCUMENT

CODE 26512

PREPARED BY: J.T. Fulton 15 July 74	TECHNICAL APPROVAL:
CHECKED BY:	APPROVED BY:
DEPARTMENT:	APPROVED BY:
SECTION:	APPROVED BY:

REVISIONS

DATE	REV. BY	REVISIONS & ADDED PAGES	REMARKS

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BETHPAGE, NEW YORK 11714

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ATTACHMENTS

1. INTRODUCTION

The initial Earth Observation Satellite (EOS-A) will be flown in a low altitude sun synchronous earth orbit and will carry a payload consisting of a number of instruments primarily in support of the Land Resources Management Mission (LRM).

The EOS-A spacecraft will consist of:

The Vehicle
The Instruments
The Data Management System
The Instrument Mission Peculiars

1.1 Scope

This document defines all interface characteristics and related data applicable to the above listed payload items and the:

Spacecraft
Mission Peculiar Data Links
Primary Ground Station
Low Cost Ground Stations
DCS Transmitters and Receiving Stations

which are required to assure compatibility of these elements and to permit GAC and (Contractor) to proceed in their analysis, design, manufacturing and flight support activities.

These data contained herein are binding and subject to any parties right to an equitable adjustment under the terms of his contract with the procuring agency. Following implementation of this document, data may be added, changed or deleted only as provided for in the "Space Vehicle System Integration Plan".

All schedules affecting the interface will be as reflected in each contractor's Program Master Schedule, which must be in agreement with the overall program Interface Milestone Schedule.

1.2 Instrumentation Options

This document is meant to encompass all interface considerations applicable to each and all payload instruments. Where an alternate interface is required for a specific instrument, a separate paragraph shall be provided herein which will exhibit the same paragraph number but will contain a single letter prefix according to the following table:

TM	T
HRPI	H
DCS	D
SAR	S
PMMR	P

These prefixed paragraphs shall immediately follow the general paragraph.

2.0 LIST OF ACRONYMS

ACM	Attitude Control Module
ACS	Attitude Control System
AGE	Aerospace Ground Equipment
AOP	Advanced On-Board Processor
ARC	Absolute Radiometric Calibration
ATS-F	Applied Technology Satellite F
BER	Bit Error Rate
B/L	Baseline
BST	Boresighted Star Tracker
BPSK	Biphase Shift Keying
CC	Control Center
CCP	Ground Control Points
C&DH	Communications & Data Handling
CDP	Central Data Processing
CIPS	Conical Image Plan Scanner
CMD	Command
CMD/TLM	Command/Telemetry
CPF	Central Processing Facility
CSC	Computer Sciences Corporation
DMS	Data Management System(s)
DOD	Department of Defense
DOMSAT	Domestic Satellite
DPS	Data Processing System
EBR	Electron Beam Recorders
ELMS	Earth Limb Measurements Satellite
EOS	Earth Observatory Satellite
ERTS	Earth Resources Technology Satellite
FHT	Fixed Head Tracker
FMEA	Failure Mode Effects Analysis
FOM	Figure of Merit
FSK	Frequency Shift Keying
FSS	Flight Support System
GAC	Grumman Aerospace Corporation
GFE	Government Furnished Equipment
GLS	Ground Logistics System
GPS	Ground Processing System
GSE	Ground Support Equipment
HPRI	High Resolution Pointable Imager
ICD	Interface Control Document
IMPATT	Impact-Avalanche and Transit Time
IMS	Information Management System
LBR	Laser Beam Recorder
LCGS	Low Cost Ground System
LIPS	Linear Image Plane Scanner
LOPS	Linear Object Plane Scanner
LRM	Land Resource Management
LSA	Limited Space Charge Accumulation
L/V	Launch Vehicle
MLI	Multi Layer Insulation
MOMS	Multi-Megabit-Operation Multiplexer System
MSS	Multi Spectral Scanner
MUS	Magnetic Unloading System
MUX	Multiplexer
NASCOM	NASA Communications
NEFD	Noise Equivalent Flux Density
NM	Nautical Mile
NRZL	Non Return to Zero Level
NTTF	NASA Test & Training Facility
NUS	No Upper Stage
OAO/LST	Orbiting Astronomical Observatory/Large Space Telescope
OAS	Orbit Adjust Subsystem
OBC	On-Board Computer
OBDC	On-Board Data Compaction
OPS	Operations
OTS	Orbit Transfer Subsystem
OWS	Orbital Workshop (Skylab)
PCM	Pulse Code M dulation
PCU	Power Control Unit
PDSS	Precision Digital Sun Sensor
PDU	Power Distribution Unit
PFD	Power Flux Density
PGST	Precision Gimballed Star Tracker
P/L	Payload
PMMR	Passive Multichannel Microwave Radiometer
PRN	Pseudo Random Noise
PRU	Power Regulation Unit
PSK	Phase Shift Keying
PSM	Power Supply Module
QPSK	Quadraphase Shift Keying
REL	Reliability
RF	Radio Frequency
ROM	Read Only Memory
R & QA	Reliability & Quality Assurance
RS	Resupply System
RTC	Real Time Commands
RTS	Remote Tracking Site
SAMS	Shuttle Attached Manipulator System
SAR	Synthetic Aperture Radar
S/C	Spacecraft

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LIST OF ACRONYMS (Cont'd.)

MBPS	Megabits Per Second
MEM	Module Exchange Mechanism
MEM	Multiplexer/Encoder Module
SM	Subsystem Module
SMM	Solar Maximum Mission
SMS	Synchronous Meterological Satellite
SNR	Signal-Noise Ratio
SOW	Statement of Work
SRM	Solid Rocket Motor
SSR	Scanning Spectral Radiometer
STAB	Space Transportation & Budget
STDN	Space Tracking Data Network
S/V	Space Vehicle
TDRS	Tracking & Data Relay Satellite
TBD	To Be Determined
TBS	To Be Supplied
TEA	Transferred Electron Amplifier
TEO	Transferred Electron Oscillator
T IIID	Titan IIID
T & IS	Test & Integration Station
TM	Thematic Mapper
TRAPATT	Trapped-Plasma-Avalanche Triggered Transit
TWTA	Traveling Wave Tube Amplifier
WBS	Work Breakdown Structure
WBVTR	Wide Band Video Tape Recorder
SCO	Sub-Carrier Oscillation
SEASAT	Sea Satellite
SEOS	Synchronous "EOS"

DEFINITIONS

S/V -Spacecraft and Launch Vehicle

Basic S/C-Standard Modules

S/C Payload-Instruments

β -Beta angle is the minimum angle formed by the earth sun line and the orbit plane

INTERFACE CONTROL DOCUMENT	SHEET 10 OF 53	ICD NO.	REV.

3.0 Applicable Documents

The applicable documents for each contractor are as specified in his individual contract. In addition, the following documents of the exact issue shown, form a part of this ICD to the extent specified herein.

3.1 GAC Documents

ELMS-112-RP-001	Orbital Requirements Document
EOS -113-PL-001A	Space Vehicle System Integration Plan
GAC CDRL Item A038	Contamination Prevention and Control Program Plan

3.2 Specifications

MIL-R-5757F	Relay, Electrical, General Specification for
MIL-C-38999D	Connector, Electrical, Circular, Miniature, High Density Quick Disconnect
MIL-C-83723B	Connector Electric, Circular Environment Resisting, General Specification for

3.3 Military Standards

MIL-STD-1246A	Product Cleanliness Levels and Contamination Control Programs

3.4 SAMSO Documentation

SAMTECM 80-1	Range Users Handbook
SAMSOM 127-8	Safety Engineering
SAMTECM 127-1	Range Safety Manual
SSD Exhibit 61-47B, 1 Apr. 66	Computer Program Subsystem Development Milestones
SSD Exhibit 61-98B	Orbital Requirements Document

3.5 Other Publications

FED-STD209a 10 Aug. 1966	Cleanroom and Work Station Requirements, Controlled Environment
NASA Rpt. CR-89557	Polymers for Spacecraft Applications
TOR-1001-(2307)-4 Reissue B 15 Aug. 1972	Electromagnetic Requirements for Space Systems

4. MISSION DESCRIPTION

4.1 Space Vehicle Configuration

The EOS-A Space Vehicle configuration for the launch and on-orbit phases of the mission shall be as shown in Figure 4-1.

4.1.1 Launch Configuration

At launch, the space vehicle shall consist of;

1. An instrument payload assembly whose configuration is completely mission peculiar and independent of the subsystem structural and thermal design.
2. A subsystem structural assembly whose function it is to contain the subsystem modules and to ultimately provide the structural interface for shuttle resupply activities. The subsystem modules include;
   a. The power supply subsystem
   b. The stabilization and control subsystem
   c. The communications and data handling subsystem (non mission peculiar)
   d. The pneumatics/orbit adjust subsystem
3. A transition ring assembly which functions as the structural interface between the subsystem assembly and mission peculiar instrument payload assembly. It is the function of the transition ring assembly to transfer all launch loads from the instrument assembly and the subsystem assembly directly to the launch vehicle. In this manner, both the subsystems and instrument assemblies are designed to carry only their own loads.

As shown in Figure 4-1, the space vehicle shall be mounted atop the booster's adapter and enclosed within the fairing. The latter's dimensions dictate that the space vehicle's solar array assembly shall be folded into its stowed positions. In addition, the payload sensor's thermal cooler and aperture cover shall be closed at launch.

4.1.2 On-Orbit Configuration

During the ascent phase of the mission the fairing shall be jettisoned and the space vehicle shall be separated from the booster at the spacecraft/space vehicle adapter interface, the space vehicle adapter remaining with the booster. The GN_2 thrusters shall then null out any space vehicle angular rates. Following coast to

apogee, the solid rocket motor shall be fired to achieve orbit circularization and shall then be jettisoned by separation at the spacecraft/solid rocket motor assembly interface. The solar array assembly, the payload sensor's aperture thermal cooler cover and shield shall then be deployed, resulting in the on-orbit configuration shown in Figure 4-1.

4.2 Space Vehicle Operation

4.2.1 Orbits/Mission Duration

The EOS-A space vehicles shall be launched from pad TBD at TBD into the orbits given in table 4-1. Following insertion, the EOS-A shall operate in the established orbit for approximately 90 days prior to re-establishment of the nominal orbit by means of the orbit adjust subsystem. Re-establishment will occur approximately every 90 days.

Mission	Launch Date	Launch Time	Mean Altitude	Ellipticity	Perigee Location	Inclination & RT ascens. of of Asc. Node
				TBD		

TABLE 4-1

4.2.2 Prelaunch Operation TBD

4.2.3 On-Orbit Operation

Following insertion, the satellite shall be stabilized in the pitch=yaw=roll=0^{o} attitude shown in Figure 4-2 for deployment of the solar array assembly and operation of the sensors.

The payload shall be available for operation continuously during the mission (except for emergency space vehicle survival modes).

The spacecraft shall maintain stabilization relative to the nominal local vertical to within the following 30 values throughout the operating period. The nominal local vertical shall be correct within + 0.01* degrees (1 sigma) in each plane.

Parameter	Angle	Rate of Change
Roll	10μ RAD 2 $\widehat{sec}$	+ 0.175μ RAD/SEC + 10^{-5} o/sec
Pitch	10μ RAD 2 $\widehat{sec}$	+ 0.175μ RAD/SEC + 10^{-5} o/sec
Yaw*	10μ RAD 2 $\widehat{sec}$	+ 0.175μ RAD/SEC + 10^{-5} o/sec

* Tolerance important to data reconstruction. Currently 3.5 $\widehat{sec}$ - 18μ RAD.

The spacecraft position along the orbit shall be known following ground calculation to 40 meters (one sigma)

The spacecraft local altitude above the (TBD) geoid shall be known following ground calculation to 40 meters (one sigma). The local altitude shall be available in predicted form on board the spacecraft in real time to an accuracy of 40 meters (one sigma).

4.2.3.1 Sensor Scan Geometry

The scan geometry of the TM shall be as illustrated in Figure (a).

The scan geometry of the HRPI shall be as illustrated in Figure (b).

4.2.3.2 DCS Survey Area

The survey area within which a standard platform can be sensed with a reliability of TBD and an error rate of TBD is illustrated in Figure .

4.2.3.3 Payload Calibration

The optical instruments on EOS shall be calibrated during the active scan intervals on command.

Provision shall be made to perform intermediate level calibration without requiring changes in vehicle attitude.

If necessary, a more fundamental calibration may require rolling of the spacecraft in order to scan deep space or the moon.

The intermediate calibration shall be commandable at the end and/or beginning of each data pass if required.

The calibration shall consist of an electronic and optical portion as indicated in Figure .

During calibration, a calibration word will be transmitted in accordance with the high level MVX plan of section 5.4.4.2. The word will be (TBD).

During the electronic portion of the calibration, a 512 step reference staircase will be introduced into each detector preamps while the detector is seeing black. The zero level of this staircase shall correspond to the D. C. restoration level. The highest step shall correspond to the highest brightness level the instrument is required to handle. Each step of the staircase shall last for 4 pixel time intervals to allow adequate settling.

During the optical portion of the intermediate level calibration, a bar chart shall be introduced into the optical path containing at least six non-chromatic grey levels. Each grey level shall be at least 10 pixels long.

5. SPACECRAFT/INSTRUMENTS INTERFACES

5.1 Instruments Physical Characteristics

The instruments shall consist of one each of three individual assemblies:

- The Thermatic Mapper (TM)
- The High Resolution Pointing Imager (HRPI)
- The Data Collection System (DCS)

5.1.1 Envelopes

The external dimensions, mounting provisions, electrical and fluid connections and the locations of the centers of gravity of the payload assemblies shall be as shown in Figures 5.1-1 through 5.1-5.

5.1.2 Weights

The maximum weights of the payload assemblies shall be as follows:

- TM 350 Lbs.
- HRPI 400 Lbs.
- DCS 80 Lbs.

5.1.3 Moments of Inertia

The moments of inertia of the payload assemblies about their centers of gravity shall be as given in Table 5.1-1.

Table 5.1-1
Payload Moments of Inertia

Payload Assembly	Moments of Inertia (in-lbs-sec^2)		
	X-X Axis *	Y-Y-Axis *	Z-Z Axis *
Sensor			
Off-Sensor Electronics			
Power Supply			

5.1.4 Surface Characteristics

5.1.4.1 External Surfaces (Reserved)

5.1.4.2 Mounting Surfaces

The instruments shall be mounted to the spacecraft at finite points which will not provide a thermal sink.

A star tracker shall be mounted and aligned to the TM at a mounting plate provided. This surface shall have a flatness of 0.010 inches with a surface finish

----
*Referenced to spacecraft axes as shown in Figure 4-1 for the installations shown in Figures 5.3-1 and 5.3-3.

of 63 micro-inches. The mounting surface shall be uncoated aluminum. This interface shall also be designed to avoid heat transfer between the packages.

5.1.5 Natural Frequency

The lowest natural frequency of the payload sensor shall exceed 22 Hz if cantilevered from a rigid mount.

5.1.6 Uncompensated Momentum

When changing offset angle, the HRPI shall not transfer more than TBD ft-lb-sec of momentum to the spacecraft in any TBD second interval. The HRPI shall settle to to its required pointing accuracy within 5.0 seconds after completion of an offset angle change.

5.2 Instrument Environments

5.2.1, 5.2.2, 5.2.3 Loads, Acoustic Environment and Shock Levels

The Acoustic, Vibration, Acceleration, and shock loads anticipated for this mission are described in Appendix C.

5.2.4 Temperature Levels

The external temperature levels experienced by the payload assemblies shall be as given in paragraph 5.5.

5.2.5 Pressure Levels

The instrument assemblies shall be exposed to external pressure levels ranging from the atmospheric pressure at sea level to that at 400 ± 50 nmi altitude. During the ascent phase of the mission, the rate of external pressure decay shall be as shown in Figure 2-3.

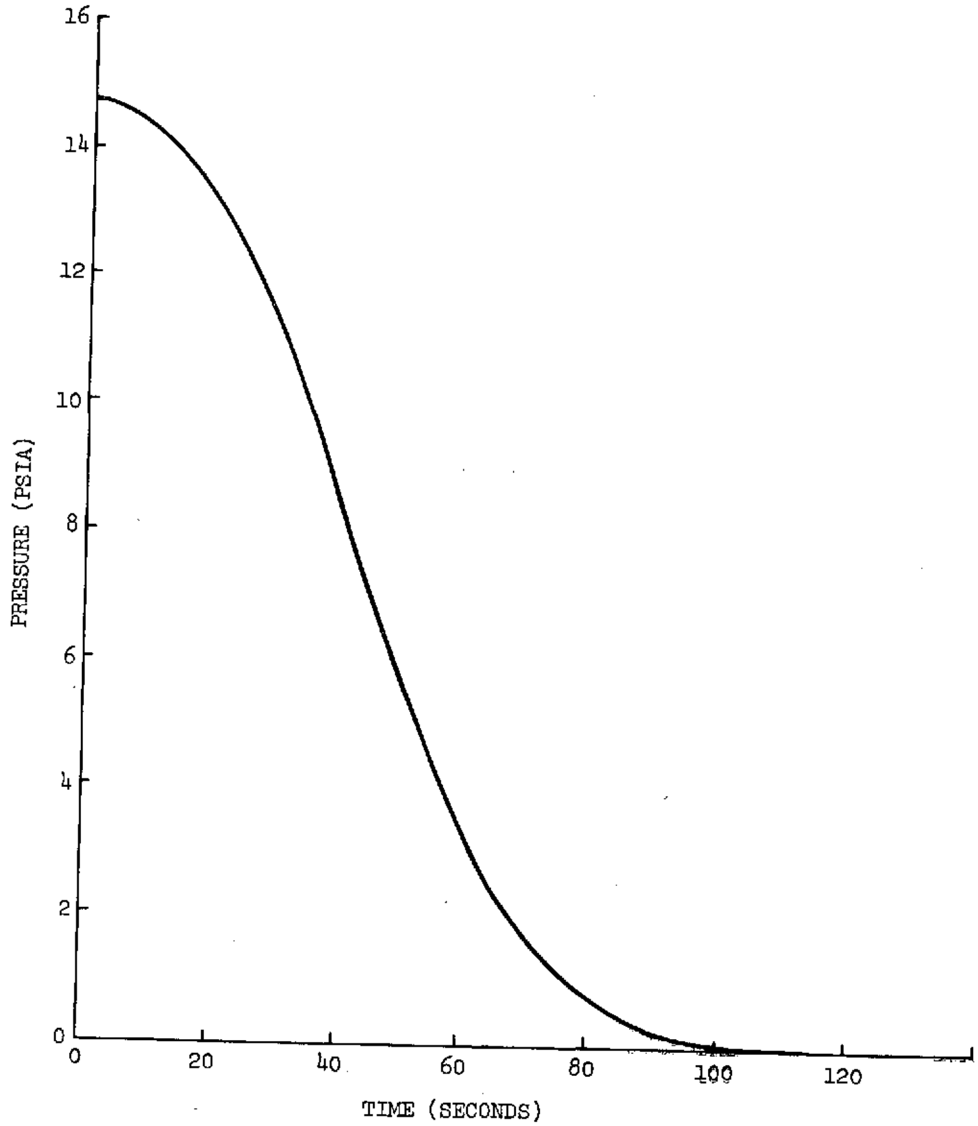
5.2.6 Solar Illumination

The external surfaces of the Instruments not shielded by other structures shall be subject to direct solar illumination as defined in Fig. TBD and earthshine as developed in Fig. TBD.

5.2.7 Cleanliness Levels

5.2.7.1 Ground Handling

Surface Cleanliness - When delivered to Grumman, the instruments shall have been cleaned to Level 100A(MIL-STD-1246A) and bagged. This level shall be main-



2-3

Fig. 2-3 Ambient Pressure Decay During Ascent

Table 5.2-2

Ground Handling Cleanliness Environments

	Payload Sensor Environment		
Location	Out of Spacecraft	Installed in Spacecraft	Remarks
1) At Grumman	Class 100 (FED-STD-209A) laminar flow bench	Class 100,000 (FED-STD-209A) cleanroom. See Remarks.	Payload sensor optical end locally bagged and purged with dry, filtered boil-off GN_2 supplied by AC.
2) During Shipment to VAFB	N/A	Spacecraft bagged within shipping container. Positive pressure maintained in container with filtered purge.	Same as location 1.
3) VAFB Payload Assembly Bldg.	Same as location 1.	Same as location 1.	Same as location 1.
4) In-Transit	N/A	TBD	TBD
5) Launch Pad	N/A	TBD	TBD

tained externally for the optical and thermal cooler ends of the optical instruments subsequent to installation in the spacecraft. The optical instrument covers shall not be opened by Grumman.

Environments - The ground operation environments to which the payload sensor is exposed after delivery shall be given in Table 5.2-2.

5.2.7.2 Flight

To minimize volatiles and particles ≥ 1 micron from reaching the sensor aperture from all possible sources in the spacecraft and payload;

- A Level 300A(MIL-STD-1246A) shall be verified for all external spacecraft and thermal and optical shield surfaces as close to launch time as possible.
- All gases expelled from the spacecraft's on-orbit thrusters and vents shall be filtered before expulsion and shall be directed away from the sensor's optical and thermal fields.of view.

- The spacecraft shall utilize only those polymeric materials which produce $\leq$1.0 percent total mass loss and $\leq$0.1 percent volatile condensable material when tested as described in NASA Report CR-89557, "Polymers for Spacecraft Applications". The interiors of hermetically sealed containers shall be exempted from this requirement.
- The spacecraft's solid rocket motor shall be jettisoned before opening the sensor cover in a geometry which minimizes residual thrust impingement on the space vehicle.
- The internal surfaces of the optical and thermal shields shall be maintained at Level 100A(MIL-STD-1246A) until as close to launch time as possible.
- Provisions shall be made to protect the interior of the optical and thermal shields from contamination which may be present inside the fairing during ascent. Mechanization of these provisions TBD.

5.3 Mechanical Interfaces (TBD)

5.3.1 Payload Sensor Installation (TBD)

5.3.1.1 Mounting (TBD)

5.3.1.2 Alignment

The yaw angle between the sensor roll axis and the velocity vector shall be less than 18 μ radians total following on orbit alignment of the sensor and star tracker.

5.3.1.3 Access (TBD)

5.3.2 Off-Sensor Electronics and Power Supply Installations (TBD)

5.3.3 Instrument Optical Shield

The spacecraft shall provide an optical shield which minimizes the energy entering the sensor's aperture from sources outside the sensor's field of view.

The internal geometry and surface characteristics of the sensor optical shield shall be as shown in Figure TBD. The angular relationships shown between the shield and the sensor aperture shall include all distortions due to manufacturing and deployment tolerances plus thermal gradients.

The temperature of the shield's inner surfaces shall be as described in paragraph 5.5.3.2.

TABLE 5.4-1T

POWER REQUIREMENTS - TM

Mode	Power in Watts		
	Data Collection	Sensor Calibrate	Cover Open
Total Power Input to Payload*	(TBD)		
Duty Cycle	(TBD)		
Remarks	(TBD)		

* Input to Power Supply only. All other boxes receive power from the Power Supply

TABLE 5.4-1H

POWER REQUIREMENTS - HRPI

Mode	Power in Watts		
	Data Collection	Sensor Calibrate	Cover Open
Total Power Input to Payload*	(TBD)		
Duty Cycle	(TBD)		
Remarks	(TBD)		

* Input to Power Supply only. All other boxes receive power from the Power Supply

TABLE 5.4-1D

POWER REQUIREMENTS - DCS

Mode	Power in Watts		
	Data Collection	Sensor Calibrate	Cover Open
Total Power Input to Payload*	(TBD)		
Duty Cycle	(TBD)		
Remarks	(TBD)		

* Input to Power Supply only. All other boxes receive power from the Power Supply

5.3.4 Instrument Thermal Shield (TBD)

5.4 Electrical/Electronic Interfaces

5.4.1 Electrical Power Interface

The spacecraft and each instrument shall have only one functional electrical power interface, which shall be between the spacecraft's Power Distribution Unit (PDU) and the Instrument Power Supply assembly. All electrical power for the instrument sensor assembly and the off-sensor electronics assembly shall be furnished to them from the instrument power supply assembly. All power shall be distributed by a two-wire system (power and return). There shall be no sharing of power leads (positive or negative) carrying current to two or more equipments. During pre-launch operations, the spacecraft shall have the capability to permit removal of the instrument.

5.4.1.1 Instrument Power Requirements

The electrical power required by the payload shall be as listed in Table 5.4.1.

5.4.1.2 Spacecraft Power Supply Characteristics

Power to the instrument power supply assembly shall be supplied from the PDU which shall provide both a positive and a negative power bus. Power shall be supplied at 28 ± 4 volts DC.

The maximum reflected ripple voltage, generated ripple voltage, and conducted transients shall not exceed those limits specified in TOR-1001-(2307)-4B, paragraphs 3.3.3.1.1.4, 3.3.3.1.1.5, and 4.5.2.5.3, respectively.

5.4.2 Telemetry Interface

The spacecraft Pulse Code Modulators (PCM's) shall provide synch signals to the instruments for control and for shifting out the payload data. The spacecraft PCM's shall accept payload data and multiplex it into the 32 KBPS data stream as shown in Fig. 2-4.

The payload/spacecraft PCM functional interface shall be as shown in Fig. 2-5. The instrument analog multiplexer and converter (AMC) shall be capable of receiving control signals from, and transmitting data to either spacecraft PCM. A failure of one payload/PCM interface shall not affect the payload interface of the redundant PCM.

Details of the TLM interface are given in Appendix D. The TLM for each instrument is listed in Appendix E.

5.4.3 Command Interface

Details of this interface are given in Appendix D.

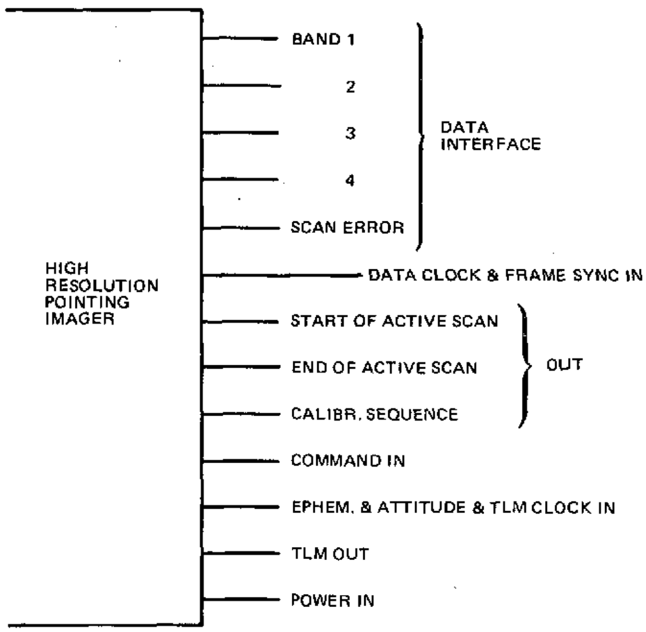
5.4.3.1 Payload Command Requirements

The commands required by the instruments shall be as listed in Appendix D.

5.4.3.2 Ancillary Data Requirements

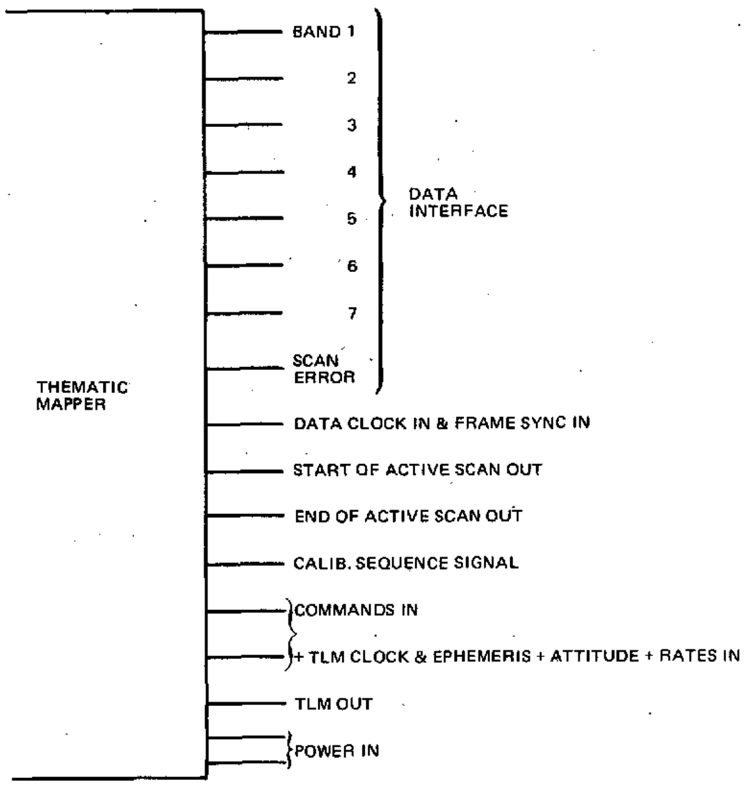
The vehicle shall provide each instrument the following mission related data during instrument operation at the interval specified

DATA	INTERVAL
Vehicle Time	TBD
Vehicle Ephemeris	TBD



2-4

Fig. 2-4 High Resolution Pointing Imager Electrical Interface



2-5

Fig. 2-5 Thematic Mapper Electrical Interface

Roll, Pitch & Yaw	TBD
Roll, Pitch & Yaw Rates	TBD

The scan error output shall be generated and updated in accordance with the above guidelines.

5.4.4 Data Interface

The TM & HRPI shall each provide individual data outputs in digital form corresponding to each spectral band. The output for each band shall be in parallel form with 6 bit accuracy.

They shall also provide in 6 bit parallel digital form a scan position error signal defining the error in pixel 1 position relative to its desired location.

They shall also provide on separate wires a pulse indicating that the start and end of scan occurs with the next data column.

They shall also provide on a spearate wire a pulse indicating when the instrument is in the calibration mode.

5.4.4.1 Wideband Data Output Characteristics.

The Thematic Mapper shall provide six separate digital output wires for each spectral band.

The HRPI shall provide six separate digital output wires for each spectral band.

These outputs shall have the following characteristics at the instrument output:

a) Data Type NRZ
b) Signal Type binary TTL
c) Amplitude TBD
d) Rise & Fall Time TBD
e) A single ended isolated return shall be provided for each output
f) PCM Load Resistance TBD
g) Clock Frequency - TBD
h) Transition Time - ± nanoseconds of the reference transition.

5.4.4.2 Wideband Data Format

The analog to digital converter generating each spectral band output shall operate at a subharmonic of the DATA CLOCK.

All output lines of a given spectral band will be updated in coincidence.

All outputs of a given instrument will be updated in coincidence.

5.4.4.3 Auxiliary Data Output Characteristics

The TM & HRPI shall each provide a pulse indicating that start of scan in accordance with Fig. TBD .

The TM & HRPI shall each provide a pulse indicating the end of active scan in accordance with Fig. 2-6.

These pulses shall be on separate lines:

a) Data Type - RZ

b) Signal Type - binary TTL

c) Amplitude - binary one = 5.0 0.5 VDC
binary zero = 0 0.5 VDC

d) Rise & fall time 50 nanoseconds
1 microseconds

e) A single ended isolated return shall be provided for each output.

f) PCM load resistance 1 megohm.

5.4.4.4 Auxiliary Data Output Format (TBD)

5.4.5 Cabling Interfaces

A functional diagram of the electrical cabling interfaces between the spacecraft and the instruments is shown in Figure 5.4-6 (TBD). All cabling shall be supplied by GAC, including cabling running only between payload assemblies.

5.4.5.1 Connectors

Connectors shall conform to MIL-C-83723B or MIL-C-38999D and shall furnish GAC the connector halves for those cables which interface with the payload assemblies.

The connectors used at the payload assembly interfaces shall be as listed in Figure 5.4-7 (TBD).

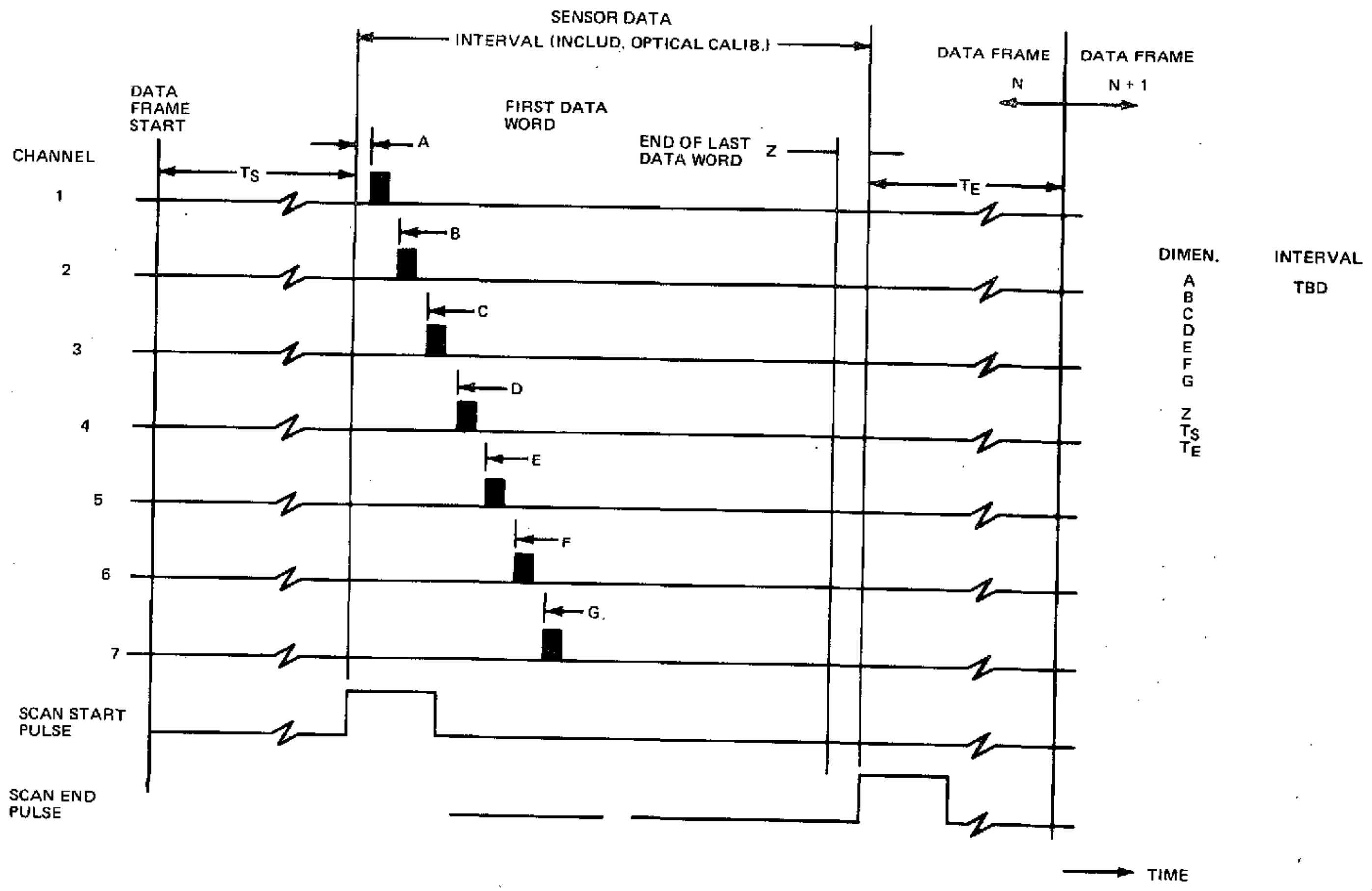


Fig. 2-6 TM Wideband Data Format Detail (C)

TBD

Fig. 2-7 Payload Sensor Temperature Signal Characteristics

5.4.5.2 Pin Assignments

Pin assignments within the electrical connectors listed above shall be as given in Appendix F.

5.4.5.3 Cabling Protection

Redundant provisions shall be made in the spacecraft to provide power to the instruments. The primary power path shall be protected by a 7.5 amp slow-blow fuse. The secondary power path shall be hard-wired. To isolate the primary path fuse from the current surge associated with opening of the payload sensor's cover, separate, unfused power wiring shall be provided for the cover motor.

To assure receipt of the cover open command, redundant relay closures will be provided by the spacecraft.

5.4.5.4 Grounding Provisions:

Grounding of the payload circuits shall be as shown in Figure 2-8.

The ground return path for all power and signal circuits shall be through conductors in the cables and not through structure. Grounding criteria shall be as specified in TOR-1001 (2307) -4B.

5.4.5.5 Cabling Configuration

The design of the spacecraft cabling interfacing with the payload assemblies shall be as shown in Appendix G.

5.4.6 Electromagnetic Interfaces

The electromagnetic compatibility of the payload shall be governed by TOR 1001 (2307) -4 Reissue B. Specific requirements other than those specified in the referenced documents shall be as follows:

5.4.6.1 Conducted EMC

Conducted Emissions - None

Conducted Susceptibility - None

Grounding - The payload grounding shall be as shown in Figure 2-8.

5.4.6.2 Radiated EMC

Radiated Emissions - The payload's radiated emissions shall not exceed TOR 1001 (2307) -4B and in addition the radiated emissions (narrow band) shall not exceed 6 db above 1 μV/M in the frequency range of 1600 MHz to 1800 MHz.

Radiated Susceptibility - There shall be no malfunction(s), change(s) in normal indication(s) or degradation(s) of performance of the payload when subjected to the tests and requirements specified in TOR 1001 (2307) -4 Section 4. The expected payload environment is as shown in Table 5.4-3 (TBD) and shall not adversely affect the payload.

5.5 Instrument Thermal Environment

5.5.1 Ground Environment

Non-Operating - During storage & installation of the payload and during storage, transportation and handling of the space vehicle, the payload shall be exposed to the following environments:

- o temperature $-40^{\circ}C$ to $+66^{\circ}C$
- o humidity 0 to 100% relative
- o pressure 0 to 15,000 Meters Ambient

Operating - During payload ground test operations, forced air cooling shall be provided as required. The properties of this cooling air are TBD.

5.5.2 Flight Environment and Requirements

The thermal design of the instrument shall be consistent with the environments and requirements specified in this section.

TBD

Fig. 2-8 Payload Grounding Schematic

5.5.2.1

The contractor shall not use the spacecraft as a heat sink or a heat source. The contractor shall minimize the thermal conduction and radiation interchange between the instrument and the spacecraft structure.

5.5.2.2

The spacecraft instrument support structure operating temperature range shall be TBD. The maximum total heat transfer between the instrument and the spacecraft by conduction shall be TBD watts.

5.5.2.3

The instrument operating temperature range shall be TBD.

5.5.2.4

The contractor shall specify heater power requirements (if any, and within limits otherwise specified). The contractor shall provide documentation, showing the sizing control, and location of all heater circuits.

5.5.2.5

The contractor shall provide documentation of all external surface thermal radiation properties (solar absorbtance, total hemispherical emittance).

5.5.2.6

GAC shall provide documentation of all pertinent external surface thermal radiation properties (solar absorbtance, total hemispherical emittance).

5.5.2.7

Detector cooling requirements shall be accomplished only by passive techniques.

5.5.2.8

The contractor shall document the location and geometry of all passive cooler surfaces.

5.5.2.9

GAC shall provide documentation specifying the location, maximum temperature and reflected heat fluxes for all surfaces which the cooler views.

5.5.2.10

The maximum orbital average radiant heat flux from all spacecraft surfaces incident on cooler surfaces shall be TBD watts.

5.5.2.11

The maximum instantaneous radiant heat flux from all spacecraft surfaces incident in cooler surfaces shall be TBD watts.

5.5.2.12

The contractor shall provide a thermal nodal model, in sufficient detail to evaluate component temperature instrument package structural distortion, and thermal interchange between the instrument and the spacecraft structure. This model shall be documented in detail, showing all thermal properties, all thermal couplings, all heat inputs, and all assumptions. The documentation format and units shall be specified by GAC. The detail and status of the model shall be consistent with the status of the program, and updated accordingly.

5.5.3.1 Payload Sensor Characteristics

a) Thermal - The thermal characteristics of the payload sensor shall be as given by the simplified thermal model shown in Figure 5.5-1. The payload sensor temperature signals described in paragraph 5.4.4.1 shall be measured at the focal plane, optical bench and the radiation shield (points A, B and C in Figure 5.5-1).

5.5.3.2 Payload Sensor Optical Shield

The geometry and internal surface properties of the optical shield shall be as described in paragraph 5.3.3. The internal surface temperatures of the shield shall not exceed those shown specified in paragraph 5.5.3.3(b).

Table 5.5-1

Payload Sensor Temperature Limits

Payload Sensor Element	Location in Fig. 5.5-1 Thermal Model	Temperature Limits (^{o}K)
Focal Plane	point A	≤
Optical Bench	point B	≤
Radiation Shield	point C	≤

TABLE 5.5-2 7

PAYLOAD THERMAL CHARACTERISTICS

Payload Assembly	Total Waste Heat * (Watts)	Thermal Capacity of Assembly (Btu/°F)
On-Sensor Electronics		
Off-Sensor Electronics		
Power Supply		

* o Minimum and maximum waste heat values are associated with minimum and maximum mounting flange temperatures, respectively.

o There shall be approximately an 80%/20% split in heat dissipation to the mounting flange and cover, respectively.

TABLE 5.5-2 H

PAYLOAD THERMAL CHARACTERISTICS

Payload Assembly	Total Waste Heat * (Watts)	Thermal Capacity of Assembly (Btu/°F)
On-Sensor Electronics		
Off-Sensor Electronics		
Power Supply		

* o Minimum and maximum waste heat values are associated with minimum and maximum mounting flange temperatures, respectively.

o There shall be approximately an 80%/20% split in heat dissipation to the mounting flange and cover, respectively.

TABLE 5.5-2D

PAYLOAD THERMAL CHARACTERISTICS

Payload Assembly	Total Waste Heat * (Watts)	Thermal Capacity of Assembly (Btu/°F)
On-Sensor Electronics		
Off-Sensor Electronics		
Power Supply		

* o Minimum and maximum waste heat values are associated with minimum and maximum mounting flange temperatures, respectively.

o There shall be approximately an 80%/20% split in heat dissipation to the mounting flange and cover, respectively.

6.0 INSTRUMENT PAYLOAD GSE INTERFACES

The Instrument GSE interfaces with the spacecraft, spacecraft GSE and test sites shall be as defined in this section.

6.1 Required Instrument GSE Items.

AC shall provide the following payload GSE items for support of the payload subsequent to its delivery to Grumman.

Payload AGE Item	Item Name
1	Shipping Container
2	Handling Sling
3	Handling Fixture
7	Control & Display Console
8	Lockout Box

The functions, interface characteristics and requirements of each of the above payload GSE items shall be as defined below.

6.1.1 Shipping Container

The Shipping Container shall protect the payload assemblies during transportation at the assembly level (i.e. - other than while installed in the spacecraft). The Shipping Container shall be capable of housing all payload assemblies simultaneously. The sensor assembly shall be orthogonally isolated from the outer case of the Shipping Container with (TBD) Hz isolators.

The Instrument assembly shall be bagged and sealed in a Class 100 (FED-STD-209A) clean room prior to installation in the Shipping Container, and the sealed bag shall be preserved while in the Shipping Container. The Container shall be provided with seals to maintain the cleanliness of the inside environment during transportation. Removal of the sensor assembly from the Shipping Container shall be accomplished such as to maintain the cleanliness level inside the sealed bag.

Physical Characteristics

Envelope (maximum)	7 ft. long x 5 ft. x 5 ft.
Weight (maximum, including payload assemblies)	1000 lbs.

Electrical Support Requirements

None

Fluid Support Requirements

None

Other Operational Requirements

None

6.1.2 Handling Sling

A Sling shall provide for handling the sensor assembly during its installation in, or removal from the spacecraft. Installation or removal of the sensor assembly shall be accomplished by lowering or raising it while vertically suspended from an overhead crane by means of the Handling Sling. The latter shall attach to the sensor's handling eyebolts. During installation or removal, the spacecraft shall be oriented with sensor mounting surface horizontal.

Physical Characteristics

Geometry
Weight

(TBD)

Electrical Support Requirements

None

Fluid Support Requirements

None

Other Operational Requirements

To ensure that the handling eyebolts on the sensor assembly are not overloaded, the force applied to the Handling Sling shall not exceed 600 lbs.

6.1.3 Handling Fixture

A Fixture shall provide for handling the sensor assembly when not installed in the spacecraft. The Handling Fixture shall permit the access to the sensor required to perform pre-installation checkouts and shall be equipped with wheels to permit moving the sensor about the space vehicle assembly area.

Physical Characteristics

Envelope (maximum)
Weight (maximum)

Electrical Support Requirements

(TBD)

None

Fluid Support Requirements

None

Other Operational Requirements

None

6.1.4 Control and Display Console

The Control and Display Console shall provide for:

- Power, command and monitoring of the Instrument during tests performed with the Instrument out of the spacecraft.

- Monitoring of the Instrument during tests performed with the Instrument installed in the spacecraft. (During these tests, all commands shall be is-via the GAC AGE Command Generator. All Instrument commands shall be verifi-sussed prior to issuance by GAC. A positive interlock on the GAC Command Generator shall physically prevent GAC from by-passing the verification).

The Control and Display Console shall provide Instrument monitoring:

- When hardlined to the Instrument when testing the latter out of the spacecraft.
- When hardlined to the Instrument via the spacecraft checkout panel when testing the Instrument installed in the spacecraft.
- When receiving R.F. link data from the spacecraft's Carrier I antenna via the GAC AGE Front End Unit.

Instrument monitoring shall include decoding and displaying Instrument data in the determined format.

The Control and Display Console shall be equipped with lifting rings, hold down rings and locking wheels.

Physical Characteristics

Envelope (maximum)	(TBD)
Weight (maximum)	1000 lbs.

Electrical Support Requirements

Power	Two duplex outlets, each 115 VAC, 60 Hz, single phase, 15 amps, grounding through interface connector.

Interface Connectors

a) Power	Standard 3 wire AC plug
b) Hardlined data from spacecraft checkout panel	(TBD)
c) Hardlined data from GAC AGE Front End Unit	(TBD)

Fluid Support Requirements

None

Other Operational Requirements

Checkout Panel Requirements - The following Instrument signals shall be available at the spacecraft checkout panel: (TBD)

6.1.5 Lockout Box

The Lockout Box shall provide for monitoring of the sensor assembly's focal plane temperature and for inhibiting inadvertent opening of the sensor cover or inadvertent application of bias voltage to the sensor detectors. The Lockout Box shall be hardwired to the Instrument. When the Instrument is installed in the spacecraft, hardwiring shall be accomplished through the spacecraft umbilical connector.

Physical Characteristics

Envelope (maximum)	(TBD)
Weight (maximum)	(TBD)

Electrical Support Requirements

Power	None
Signal Input Connector	(TBD)

Fluid Support Requirements

None

Other Operational Requirements

Umbilical Requirements - The following Instrument signals shall be available through the spacecraft umbilical:

Instrument Signal	Wiring Required
Detector Bias Lockout and Return	2 lines
Cover Drive Lockout and Return	2 lines
Focal Plane Temperature Monitor	4 lines
	Total = 8 lines

6.2 Instrument GSE Utilization

6.2.1 Test Site Requirements

Instrument GSE items shall be provided at the test sites as shown in Table 6.2-1. Figures in parentheses indicate quantities of each item required. Transportation of payload GSE items to the test sites shall be the responsibility of the instrument vendor.

Table 6.2-1 T

~~=~~ TM AGE Requirements

Payload AGE Item	Test Site	
	GAC	~~VAFB~~
Shipping Container	(1)	
Handling Sling	(1)	
Handling Fixture	(1)	
Control and Display Console	(1)	(1)
Lockout Box	(1)	(1)

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Table 6.2-1 H

~~-~~ HRPI AGE Requirements

Payload AGE Item	Test Site	
	GAC	~~VAFB~~ ___
Shipping Container	(1)	
Handling Sling	(1)	
Handling Fixture	(1)	
Control and Display Console	(1)	(1)
Lockout Box	(1)	(1)

Table 6.2-1 D

DCS AGE Requirements

Payload AGE Item	Test Site	
	GAC	___
Shipping Container	(1)	
Handling Sling	(1)	
Handling Fixture	(1)	
Control and Display Console	(1)	(1)
Lockout Box	(1)	(1)

6.2.2 AGE Interconnections

The functional arrangements of the payload AGE to the payload and to the spacecraft during testing at GAC are shown in Figures 6.2-1 and 6.2-2. The arrangements during testing at VAFB are shown in Figure 6.2-3. These figures also indicate the location of payload AGE within the test sites and the lengths and suppliers of interconnecting plumbing and cabling.

The payload AGE interconnect cabling diagram is shown in Figure 6.2-4.

6.3 Spacecraft AGE Characteristics

The characteristics of the spacecraft AGE with which the payload AGE interfaces shall be as defined in the following paragraphs.

6.3.1 R.F. Front End Unit

When the payload is monitored via the spacecraft's R.F. downlink, the GAC R.F. Front End Unit shall supply the Carrier I data stream to the AC Control and Display Console. The characteristics of this interface shall be as follows;

Data Rate:	32 KbS
Data Code:	NRZ-L
Impedance:	92 OHMS
Level:	4.0 Vpp (Nominal)
Output Polarity:	Selected Normal or Invert.
Configuration:	Single Ended (RG-62 or Equiv.)

6.4 GAC Test Site Facility Characteristics

The characteristics of the GAC facility with which the payload AGE interfaces shall be as defined in the following paragraphs.

6.4.1 Mechanical Characteristics

GAC shall provide space for the installation of payload AGE items which permits access to the items for their normal operation and maintenance and which is compatible with the proximity requirements of the items to the payload and to each other as defined in paragraph 6.1. Provisions shall be made for securing payload AGE items in their operating locations as required.

GAC shall provide lifting and transportation apparatus for moving the payload GSE within the GAC facility as required.

6.4.2 Electrical Characteristics

In addition to the electrical support requirements for payload GSE specified in paragraph 6.1, the GAC facility shall include the following:

Fig. 2-9 Payload Testing at Grumman With Payload Out of Spacecraft

(TBD)

Will show payload AGE items involved, functional relationships to each other, to the payload, to GAC AGE and to the GAC facility. Will also indicate location of payload AGE within the GAC facility and the lengths and suppliers of interconnecting plumbing and cabling.

Fig. 2-10 Payload Testing at Grumman With Payload In Spacecraft

(TBD)

Will show payload AGE items involved, functional relationship to each other, to the payload and spacecraft, to GAC AGE and to the GAC facility. Will also indicate location of payload AGE within the GAC facility and the lengths and suppliers of interconnecting plumbing and cabling.

Fig. 2-11 Payload Testing at VAFB With Payload In Spacecraft

(TBD)

Will show payload AGE items involved, functional relationships to each other, to the payload and spacecraft, to GAC AGE and to the VAFB facility. Will also indicate location of payload AGE within the VAFB facility and the lengths and suppliers of interconnecting plumbing and cabling.

Fig. 2-12 Payload AGE Interconnect Cabling

(TBD)

Will show payload AGE items and electrical cabling interfacing with spacecraft, spacecraft AGE, GAC test facility and VAFB test facility. Will designate connectors utilized at the payload AGE interfaces.

- Power - 110 and 220 VAC, 60 Hz
  - 28 VDC
- Grounding - Single point grounding shall be provided for each payload GSE item in each operating location.

6.4.3 Environmental Characteristics

6.4.3.1 Pre-Installation Test Area

GAC shall provide a Class 100 (MIL-STD-209A) laminar flow tunnel for testing of the payload by AC personnel while the payload is out of its shipping container.

6.5 <u>Test Site Facility Characteristics</u>

6.5.1 Mechanical Characteristics

6.5.2 Electrical Characteristics

(TBD)

6.5.3 <u>Environmental Characteristics</u>

6.5.3.1 <u>Payload Assembly Building</u>

(TBD)

6.5.3.2 <u>Launch Operations Building (Blockhouse)</u>

(TBD)

6.5.3.3 <u>Launch Support Building (Beneath Gantry)</u>

(TBD)

6.5.3.4 Gantry

(TBD)

6.6 Payload AGE EMC Requirements

To ensure electromagnetic compatibility with the spacecraft and with the test sites, payload AGE shall meet the requirements for AGE identified in "Electromagnetic Compatibility Plan for the EOS Space Vehicle Systems Segment: EOS-116-RP-001" (GAC CDRL Item TBD).

7.0 Data Reduction Requirements

(TBD)

Will specify the requirements for real-time reduction of payload data during testing at GAC and VAFB. Requirements during flight will be specified in the "Orbital Requirements Document EOS-112-RP-001"

8.0 Interface Exchange Items

In addition to the foregoing applicable documentation and interface requirements and characteristics, the following interface items shall be exchanged between GAC and AC to facilitate and assure integration of the EOS-A payload and spacecraft.

8.1 Mechanical Interface Items

To support the analysis and test verification of the structural load interface between the Instrument and spacecraft, three "Load Cycles" shall be performed. The first two load cycles shall comprise computer analyses by General Dynamics/CONVAIR Aerospace Division of structural math models, while verification of loads shall be accomplished during GAC qualification testing of the integrated space vehicle. AC shall provide the following items for these load cycles.

8.1.1 1ST Load Cycle

AC shall provide modal data for a 246 degree of freedom sensor assembly model (6 rigid body modes plus 5 elastic modes). GD/CA shall couple these data with GAC lateral and axial one dimensional models. HRC data shall consist of a generalized mass matrix, natural frequencies and a transformation matrix relating model coordinates to spacecraft coordinates. GAC shall supply base acceleration data to AC.

8.1.2 2ND Load Cycle

AC shall provide mass and stiffness matrices on magnetic tape to GAC for a 3 dimensional mathematical model of the sensor assembly (maximum of 65 degrees of freedom). This model shall be coupled to a 3 dimensional model of the spacecraft by GAC. In addition, AC shall supply transformations relating internal loads (20 maximum) and deflections (5 maximum) to unit applied loads at the sensor assembly degrees of freedom. GAC shall supply HRC the maximum values of acceleration, internal loads, and deflection corresponding to the data supplied.

8.1.3 3RD Load Cycle

AC shall supply an instrumented dynamic simulator of the sensor assembly to GAC. This simulator shall be installed in the ELMS modal survey test spacecraft. Dynamic properties of the sensor assembly up to 50 Hz shall be simulated. AC shal shall supply mass and internal load, and deflection-transformation matrices if different from those supplied for the second load cycle. GAC shall supply maximum values of acceleration for the instrumented locations (65 degrees of freedom maximum) and maximum values of internal loads (20 maximum) and deflection (5 maximum) corresponding to the data supplied.

8.2 Electrical/Electronic Interface Items

None identified at this time.

8.3 Thermal Interface Items (Reserved)

8.4 Test Interface Exchange Items

To assist GAC in the preparation of the test procedures for integrated space vehicle testing at GAC and at VAFB, AC shall provide the checkout procedures required to verify proper payload operation and performance. These procedures shall contain, as a minimum, the following information;

- o Test Objectives
- o Required Payload AGE List
- o Payload to Payload AGE Connection Diagram
- o Pre-Test Payload Preparation required (Pump-Down, Cool-Down, Etc.)
- o Chronological Sequence of Payload Commands to be Issued and Payload Parameters to be Monitored.
- o Data Sheets
- o Success Criteria for Each Payload Test Sequence.
- o Special Instructions

Upon incorporation of the AC information in the integrated test procedures, AC shall be provided review copies of the latter prior to performance of the test.

ATTACHMENT C

INTERFACE DYNAMIC REQUIREMENTS

1.0 Scope

This Appendix defines preliminary flight dynamic environmental requirements between the Instrument and the EOS Spacecraft/Launch Vehicle.

2.0 Launch Vehicles

The EOS Spacecraft may be launched by any one of the following candidate Launch Vehicles.

- o Delta 2910
- o Weight Constrained Titan IIIB
- o Titan IIIB/NUS
- o Shuttle

3.0 Flight Dynamic Environments

3.1 General

The flight dynamic environments specified below are envelopes of those associated with the four Launch Vehicles (2.0). The vibration and Launch Vehicle induced shock are defined at the Spacecraft/Launch Vehicle interface. These Spacecraft levels shall be multiplied by measured or estimated transmissility (TBD) for vibration and shock attenuation curve (TBD) for shock response spectrum at the Instrument attachment location.

3.2 Limit Load Factors

The maximum expected limit load factors are given in Tables 1, 2, and 3. These include both dynamic and steady state conditions and are to be used for preliminary design. Figure 2-13 shows the Spacecraft coordinate system sign convention.

3.3 Acoustic Field

The critical flight periods are at launch and transonic flight regimes. The maximum expected composite of the launch and transonic flight acoustic levels are shown in Table 4.

3.4 Random Vibration

The acoustic field (3.3) at launch and transonic flight regimes generate random vibrations of the Launch Vehicle airframe and Spacecraft fairing. A portion of this random vibration is structure-borne transmitted to the Spacecraft. The maximum expected flight structure-borne random vibration at the Spacecraft/Launch Vehicle interface, is shown in Table 5. The random vibration levels for the Instrument, at the Instrument/Spacecraft mechanical interface, shall be based on the Spacecraft levels multiplied by measured or estimated tranmissibility (TBD) at the Instrument attachment location.

3.5 Sinusoidal Vibration

The sinusoidal vibration environment is an envelope of Launch Vehicle responses, at the Spacecraft/Launch Vehicle interface, resulting from excitation of the Launch Vehicle low frequency modes due to various forcing functions (i.e. Pogo, engine ignition, engine shutdown and sinusoidal transients occuring throughout the flight). The maximum expected flight sinusoidal vibration is shown in Table 6. The sinusoidal vibration levels for the Instrument, at the Instrument/Spacecraft mechanical interface, shall be based on the Spacecraft levels multiplied by measured or estimated transmissibility (TBD) at the Instrument attachment location.

3.6 Shock

Shock impulses are transmitted to the Spacecraft at separation of the Launch Vehicle stages, at engine ignition, at separation of the fairing and at separation of the Spacecraft from the Launch Vehicle, The maximum generated shock experienced by the Spacecraft, at the Spacecraft/Launch Vehicle interface, is defind by the shock response spectrum shown in Fig. 2-14.

3.6 Shock - Continued

The shock response spectrum for the Instrument, at the Instrument/Spacectaft mechanical interface, shall be based on the Spacecraft levels multiplied by measured or estimated shock attenuation curve (TBD).

In addition to the above, shock excitation will occur after Spacecraft/Launch Vehicle separation when Spacecraft on-board pyrotechnic devices are actuated. The maximum generated shock experienced by the instrument, at the Instrument/Spacecraft mechanical interface, shall be defined by a shock response spectrum (TBD).

3.7 Instrument Interface Requirements

3.7.1 Instrument Structure

The stiffness of the Instrument structure, restrained at the Instrument/Spacecraft mechanical interface, should be designed to result in fundamental frequencies greater than (TBD) Hz in the longitudinal axis and (TBD) Hz in the lateral axis. These minimum frequency criteria shall be defined by the Spacectaft Contractor in conjunction with the Instrument Contractor. The fundamental natural frequency of Instrument components, when mounted on the Instrument, should be greater than 50 Hz.

3.7.2 Mathematical Structural Dynamic Model

The Instrument Contractor shall provide a mathematical structural dynamic model of the Instrument to be integrated with the Spacecraft mathematical dynamic model developed by the Spacecraft Contractor. The mathematical dynamic model shall be developed using GFE standard-format NASTRAN program.

3.7.3 Loads Cycles

The dynamic loads analyses will be conducted between the Spacecraft Contractor and the Launch Vehicle Contractor, coupling the Instrument/Spacecraft and Launch Vehicle structural dynamics models. The Launch Vehicle Contractor

3.7.4 Loads Cycles - Continued

will compute, for all critical discrete in-flight events, displacements, accelerations, forces and moments at selected Instrument/Spacecraft coordinate locations. The dynamic loads data resulting from each load cycle analysis will be used to update the load factors (3.2).

4.0 Quality Assurance

4.1 Testing at Spacectaft Contractor's Facility

A modal survey of the Instrument/Spacecraft will be performed at the Spacecraft contractor's facility, for which a mass properties and structurally equivalent simulator to the Instrument is required.

4.2 Flight Acceptance Test

The Instrument qualification model and each flight unit shall be subjected to environmental acceptance tests in accordance with the requirements of NASA GSFC S-320-G-1, except that the acoustic test and/or random vibration (including transmissibility) tests shall be as given in Tables 4, and (TBD) respectively.

4.3 Qualification Tests

The Instrument qualification model shall be subjected to design qualification tests in accordance with the requirements of NASA GSFC S-320-G-1, except as given (TBD).

EXCEPTION # 1

The thermal vacuum test shall be a combined thermal vacuum and thermal balance test.

TABLE 1

LIMIT LOAD FACTORS

DELTA 2910 AND

WEIGHT CONSTRAINED TITAN III B

LAUNCH VEHICLES

Condition	Longitudinal X	Lateral Y or Z
Lift-off	+ 2.9 - 1.0	2.0
Main Engine Cutoff	+ 12.3	0.65

TABLE 2

LIMIT LOAD FACTORS - WTR

TITAN III B/NUS LAUNCH VEHICLE

Condition	Longitudinal X	Lateral Y or Z
Lift-off	+ 2.3 - 0.8	2.0
Stage I Shutdown (depletion)	+ 8.2 - 2.5	1.5
Stage II Shutdown (command)	+ 10.8 - 2.0	1.5

NOTES:

1. Load factor carries the sign of the externally applied load.
2. Includes both steady state and dynamic conditions.

TABLE 3

LIMIT LOAD FACTORS - PAYLOAD BAY

SHUTTLE

Condition	Directions (3)		
	X	Y	Z
Lift-off (1)	+1.7±0.6	±0.3	+0.8 +0.2
High Q Boost	+1.9	±0.2	-0.2 +0.5
Booster End Born	+3.0±0.3	±0.2	+0.4
Orbiter End Born	+3.0±0.3	±0.2	+0.5
Space Operations	+0.2 -0.1	±0.1	± 0.1
Entry	±0.25	±0.5	-3.0 +1.0
Subsonic Maneuvering	±0.25	±0.5	-2.5 +1.0
Landing and Braking	±1.5	±1.5	-2.5
Crash (Ultimate) (2)	-9.5 +1.5	±1.5	-4.5 +2.0

NOTES:

1. These factors include dynamic transient load factors.
2. These factors are ultimate and only used to design payload support fittings. The specified crash load factors shall act separately.
3. Load factor carries the sign of the externally applied load. Positive X, Y, Z directions equal forward, right and down.

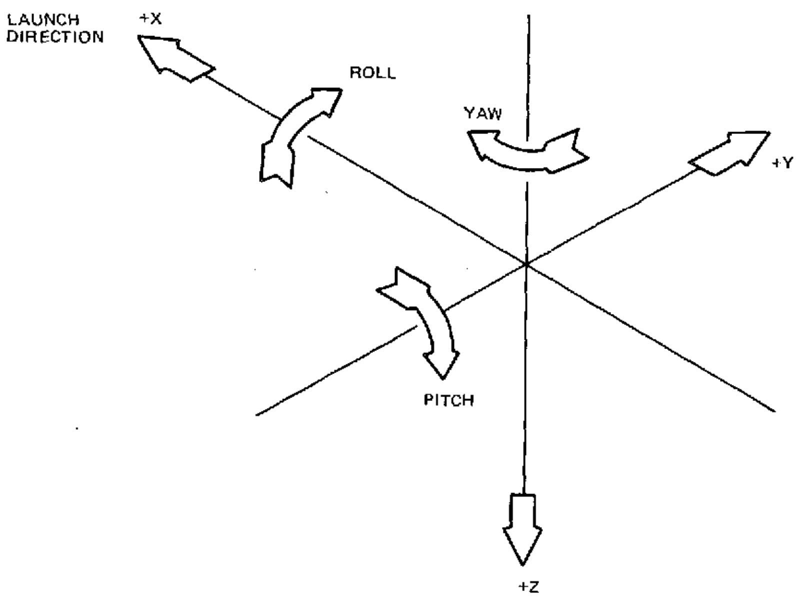


Fig. 2-13 Spacecraft Coordinate System

TABLE 4

MAXIMUM EXPECTED FLIGHT

ACOUSTIC LEVEL (INTERNAL)

* (dB Re: 20μ Newton/m^2)

OCTAVE BAND	
Center Frequency (HZ)	Sound Pressure Level (dB*)
31.5	127
63	133
125	138
250	140
500	139
1000	137
2000	133.5
4000	131
8000	129
Overall	145.5
Duration:	1 Minute

TABLE 5

MAXIMUM EXPECTED FLIGHT

RANDOM VIBRATION

Frequency Range (HZ)	Acceleration Spectral Density (g^2/HZ)	Acceleration Overall g-rms
20-500	+3dB/Oct	
500-1000	0.07	9.4
1000-2000	-6dB/Oct	
Duration:	1 minute/axis	

NOTES:

1. Input at Spacecraft/Launch Vehicle interface
2. Applied along each of the three orthogonal axes

TABLE 6

MAXIMUM EXPECTED FLIGHT

SINUSOIDAL LEVELS

Axis of Excitation	Frequency Range (HZ)	Acceleration Zero-to-peak ± (g)
Longitudinal (X-X)	5 - 9.5	8.4mm d.a.
	9.5-15	1.5
	15 -21	4.0
	21- 50	2.0
	50-200	1.5
Lateral (Y-Y) & (Z-Z)	5-7.1	12.7 mm d.a.
	7.1-22	1.3
	22-200	1.0
Sweep rate:	4 Octaves/minute/axis	

NOTES:

1. Input at Spacecraft/Launch Vehicle interface
2. Applied along each of the three orthogonal axis

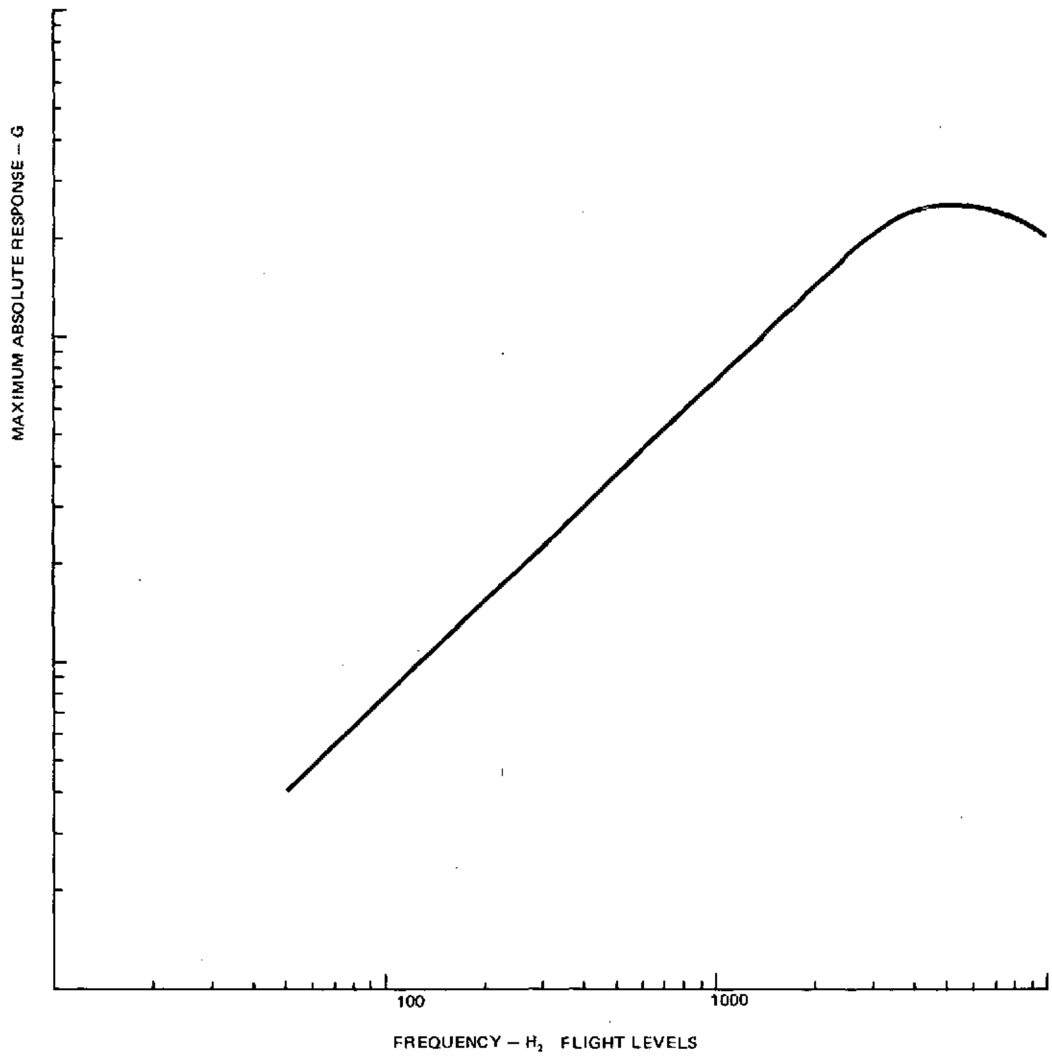


Fig. 2-14 Shock Response Spectrum at Spacecraft/Launch Vehicle Interface Launch Vehicle Induced Shocks

ATTACHMENT D

GROUP: EOS DATA HANDLING

NAME: MULTIPLEX DATA BUS SYSTEM

1.0 Functional Description:

The multiplex data bus system transmits commands, requests data and acquires data among dedicated subsystem modules onboard the EOS spacecraft as defined in Figure D-I. The system consists of a bus controller/formatter unit which functions as a traffic control device controlling the flow of command/request/data traffic to/from the remote units. It accepts commands from an onboard command decoder and an onboard computer, and transmits these to the remote units. It also requests and accepts data from the remote units and transmits this data to the communications subsystem onboard computer and/or onboard recording device.

The remote units accept commands and data request from the bus controller/formatter and distributes the commands to users. The remote units also collect conditioned reply data from a user and transmits this data via the data reply bus to the controller/formatter.

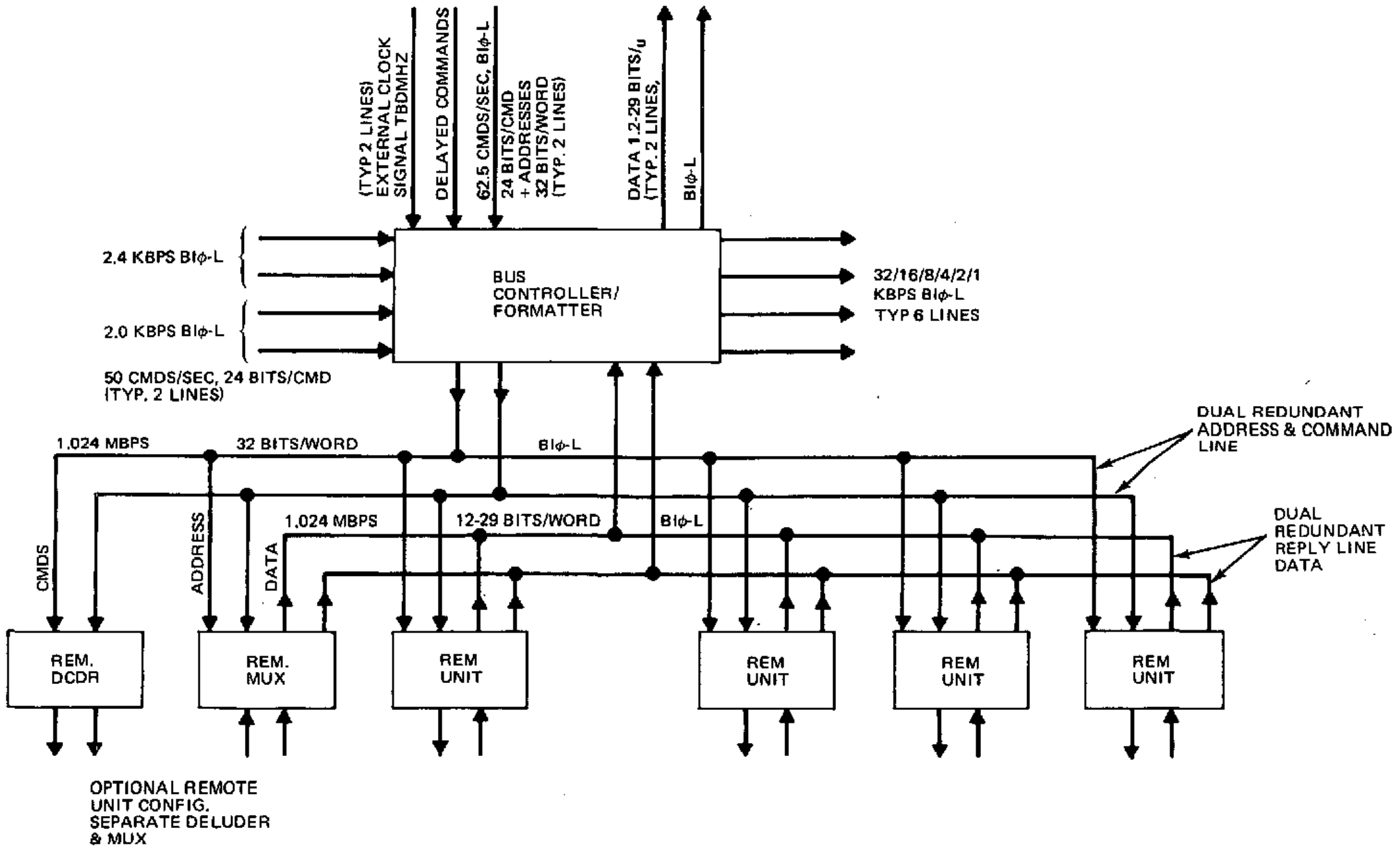
This specification is separated into four major sections:

Section 1 - Multiplex Data Bus Characteristics

2 - Characteristics Unique to the Bus Controller/Formatter

3 - Characteristics Unique to the Remote Units

4 - Characteristics etc. common to Bus Controller/Formatter and Remote Units



2-18

Fig. D-1 EOS Data Bus Configuration

SECTION I - MULTIPLEX DATA BUS CHARACTERISTICS

Transformer Coupled

Full Duplex System (Shielded Twisted Pair = 1 Bus)

One Bus Line for command and addresses from the Bus Controller/Formatter
(This line is designated The Command and Address Line)

One Bus Line for Data Return from Remote Units
(This line is designated Reply Line)

Bit Rate: 1.024 Mbps

Bit Sync: Biphase L coded data (Manchester type II)

Word Sync: 3 Bits Illegal Manchester followed by Logical "1".

Word Size: 32 Bits on Command & Address line
12 to 29 Bits on Reply Line
8, 16, or 24 Bits Data (Parity Optional)

Word Rate: 32 KHZ

*Response Time: 64 to 66 u sec.

Clock on Command and Address Line is continuous

Manchester Data on Reply Line is phased relative to Command and Address Line Bit Rate

Up to 64 Remote Units may be tied on Bus

*Response Time is defined as the time from the end of the message parity bit to the start of the return data sync word.

MULTIPLEX DATA BUS FORMAT FROM CENTRAL TO REMOTE UNIT

	BIT POS	BIT QTY	FUNCTION	
STANDARD HEADER	0-2	3	1-1/2 bits (+), 1-1/2 bits (-)	
	3	1	Fixed Logical "1"	Word Sync
	4-6	3	Specifies 1 of 8 function types	
I			FUNCTION TYPE I (Ser. Mag. CMD)	
	7-11	5	Specifies 1 of 32 Remote Units	
	12	1	Specifies Remote Unit A or B	
	13-14	2	Specifies 1 of 4 CMD Lines to User	
	15-30	16	Specifies Magnitude CMD Value	
	31	1	Parity	
II			FUNCTION TYPE II (Pulse CMD)	
	7-11	5	Specifies 1 of 32 Remote Units	
	12	1	Specifies Remote Unit A or B	
	13-16	4	Not used	
	17-22	6	Selects 1 of 64 Outputs	
	23-30	8	Not Used	
	31	1	Parity	
III			FUNCTION TYPE III (TM Address)	
	7-11	5	Specifies 1 of 32 Remote Units	
	12	1	Major Frame Indicator	
	13	1	Minor Frame Indicator	
	14	1	TM Word Indicator	
	15-16	2	Specifies 1 of 4 Signal Types	
	17-22	6	Selects 1 of 64 Inputs	
	23-26	4	Allows Expansion of 1024 Inputs	
	27-30	4	Not Used	
	32	1	Parity	

Command/Address Line Time Slot Allocations:

1. Every other 32 bit time slot on Command/Address Line is allocated to transmission of MUX* Channel Addresses (16 K Addresses/sec).

    a) Every other MUX Channel Address slot is allocated for TM transmission (8 K Addresses or 64 K bps max).

    b) Every other MUX Channel Address slot is allocated for computer use as required.

2. Every other 32 bit time slot on Command/Address Line is allocated to transmission of commands.

    a) Ground commands can only occupy every 256th slot (one per 16 ms).

    b) Pulse commands from computer can occupy only one slot per 16 ms.

    c) Serial magnitude commands from computer can occupy TBD slots per sec.

Redundancy

Buses to be redundant, Bus Controller/Formatter to transmit on selected Command/Address Bus - Remote Unit to transmit on both Reply Data Busses.

*MUX: Multiplexer section of remote unit

SECTION II - BUS CONTROLLER/FORMATTER CHARACTERISTICS

Command Execution Rate:

The Bus Controller/Formatter shall be capable of distributing 62.5 commands per second from the computer while simultaneously executing 50 commands per second from the ground.

Bus Data Rates:

Bus Controller/Formatter shall be capable of acquiring up to 32 kbps data for the computer while simultaneously acquiring up to 32 kbps of data for transmission to the ground. The 32 kbps of telemetry data shall also be fed to the computer.

Telemetry Output Format

Telemetry output data rates shall be command selectable at 32, 16, 8, 4, 2, and 1 kbps. The telemetry format shall be structured in minor frames of 128 eight bit words. For the baseline C&DH (Comm. Data Hdlg) subsystem, the telemetry format shall be controlled by the computer and as a minimum each minor frame shall contain a synchronization code, spacecraft time, command verification data, and the four subcommutator words. Capability shall exist for dwelling on the subcommutator as well as any minor frame word.

Spare Outputs:

The unit shall have 2 spare data outputs with voltage levels defined below:

Logical "1"	+12 to +17V @ 4 ma
Logical "0"	0 to + .5V

SECTION III - REMOTE UNIT CHARACTERISTICS

Remote Unit Requirements

The remote units shall be capable of providing the following signal input and output interface to users.

Remote Multiplexer

Each multiplexer (section) shall have 64 inputs that can be used for analog, bilevel, and serial digital signals. The signal handling capability shall allow a user to use any input for analogs, any input for bilevel (in groups of 8), and any of 16 inputs for serial digital signals.

All inputs of the multiplexer shall have an input impedance of 10 megohms minimum in the normal mode and 10K ohms minimum during sampling. The multiplexer shall be capable of surviving a short circuit to +35 VDC maximum or any one input for an indefinite time.

Analog Inputs (Digitized to 8 bits)

Range	0 to +5 VDC
Z Source	5K ohms maximum
Accuracy	±30 MV

Bilevel Digital Inputs

Logical "1"	+3.5 to +35VDC
Logical "0"	-1.0 to +1.5 VDC
Fault Tolerance	-20 to +40 VDC
Z Source	5K ohms minimum; 10K ohms maximum

Serial Digital Inputs (8 bits/word)

Clock Rate	64 KHz
*Gate Width	Envelopes 8 clock pulses
Input Data	
Logical "1"	+3.5 to +12 volts
Logical "0"	-1.0 to +1.5 volts
Z Source	500 ohms maximum

*These signals are multiplexer outputs with the same voltage and impedance characteristics as those shown for pulse commands in the following paragraph.

Remote Decoder

Each remote decoder (section) shall have 64 pulse command outputs and 4 serial magnitude command outputs. The reply drivers shall be packaged in groups of 4 and shall not necessarily be contained in the decoder housing. Pulse commands shall serve as relay driver inputs.

Pulse Commands

Pulse Duration	4 ms minimum
Logical "1"	+12 to +17V @ 4 ma
Logical "0"	0 to +.5V
R Source @ "0"	8.0K ohms maximum

Magnitude Commands

*Clock Rate	16 KHz
*Gate Width	Envelopes 16 clock pulses
*Command Word	16 bits serial

*These signal outputs have the same voltage and impedance characteristics as those shown for pulse commands.

Relay Driver Commands

Level	24 ±4 VDC @ 50 ma
Duration	100 ms minimum
Ground	Relay coil return provided at driver

Remote Unit Alternate Power Configuration

Remote units as per configuration #1 & #2 power strobed for economy with 16KHz square wave TBD volts ± 2%. Power "ON" only when required.

SECTION IV - CHARACTERISTICS AND PROPERTIES COMMON TO ALL UNITS

Electrical

Operating Voltage - The units shall be capable of operating from 28 ± 7 VDC external supply

Operating Voltage for remote unit alternate configuration - The remote units shall be power strobed for economy and be capable of operating from TBD volts ± 2% 16 KHz square wave.

Power -

Power shall be a minimum consistent with design requirements.

Physical Properties - Weight

The weight of all units shall be a minimum consistent with design requirements.

Operating Life: 2 years.

Basic Redundancy

The Command/Address and reply bus lines and power distribution lines shall be tolerant of any open-circuit or short to ground. This shall be achieved through the application of standby spare lines and driver circuits. In event of Command/Address line, or power line failure, repair shall be possible by switching power to the standby driver circuits.

In addition to the above base line redundancy, design on the Bus Controller/Formatter and remote units shall be based on the optional use of standby unit redundancy. Design of "black box" interfaces shall permit variations of subsystem redundancy for specific mission requirements by the addition of redundant assemblies to the standard module configuration.

Test Connectors

Test connectors shall be provided as applicable on all units. The test connectors shall provide the capability, to the maximum extent possible, to determine the flight worthiness of the assembly without the need for demating connectors in flight circuits.

Test points on an individual assembly shall be brought out to connectors used for test only. Low level circuits or those susceptible to noise or capacitive loading of the test cable may be terminated at the test connector on the assembly.

Commands

The following commands are required by the instruments. All commands are real time, occur during ground station contact, unless indicated.

Command	TM	HRPI	Comment
*Mirror Oscillation Rate (Probably Binary)			
*Primary Power On			
*Redundant Power On			
*Telemetry Power On			
*Power Off			
*Focus Forward			
*Focus Reverse			
*Focus Off			
*Electronic Calibration On			
*Radiation Calibration On			
*Calibration Off			
*Heater Control On			
*Heater Control Off			
*Bands 1-7 Power On			
*All Bands Off			
*Bands (1-7) Gain Normal (Total of 7 commands) (If Used)			
*Bands 1-7 Gain High (If Used) (Total of seven commands)			
*Turn On Outgassing Heater (RAD)			
*Turn Off Outgassing Heater (RAD)			
*Scan Monitor On			
*Scan Monitor Off			
*Scan Monitor Source A ON, B OFF			
*Scan Monitor Source B ON, A OFF			
*Cooler Door OPEN DIRECTION			
*Cooler Door CLOSE DIRECTION			
*Cooler Door Motor ON			
*Cooler Door Motor OFF			
*Cooler Door RESET			
*Cooler Door ACTIVATE			
*Cooler Door Hold ON			
*Cooler Door Hold OFF			
*Cooler Door Override Safety SAFE			
*Cooler Door Override Safety ARM			

Command	TM	HRPI	Comment
*Scan Mirror NORMAL			
*Scan Mirror INHIBIT			
*Aperture Door OPEN DIRECTION			
*Aperture Door CLOSE DIRECTION			
*Aperture Door Motor ON			
*Aperture Door Motor OFF			
*Aperture Door MOVE			
*Aperture Door RESET			
*Aperture Door ACTIVATE			
*Aperture Door Hold ON			
*Aperture Door Hold OFF			
*Aperture Door Override Safety SAFE			
*Aperture Door Override Safety ARM			
*Pointing Position			
*Pointing Activate			
*Pointing Position Drive A			
*Pointing Position Drive B			
*Scanner Detent Solenoid A			
*Scanner Detent Solenoid B			

ATTACHMENT E

The following telemtry points will be sensed and formatted by the Instrument TLM ENCODER for transmission to the mission control center.

#	TLM POINT	TYPE	FREQUENCY	COMMENT
1-63	Command Verification	Binary		
64-71	Command Verification	Multi		
72	* Focus Limit On/Off			
73	* Shutter Sync Driver Integrator Output			
74	* Cooler Stage 1 Temperature			
75	* Cooler Stage 2 Temperature			
76-79	* Structure Temperature Sensor Outputs (4)			
80	* Band 7 Detector Bias			
81	* Heater Power			
82	* Output of Low Voltage Power Supply			
83	* Input Voltage			
84	* Temperature of Scan Mirror Regulator			
85	* Temperature of Scan Mirror Drive Electronics			
86	* Temperature of Scan Mirror			
87	* Calibration Lamp Current			
88-94	* Bands (1-7) Supply Voltages			
95	* Scan Mirror Voltage			
96	* Scan Mirror Drive Output			
97-110	* Power Supply Voltages (7-10)			

APPENDIX C

APPENDIX C

PAGE 1 OF 14

CONTRACT REQUIREMENTS	CONTRACT ITEM	MODEL	CONTRACT NO.
		EOS	

REPORT

NO. EOS-113-PL-001 DATE: 15 July 74

SPACE VEHICLE

INTEGRATION PLAN

CODE 26512

PREPARED BY: J.T. Fulton

CHECKED BY:

DEPARTMENT:

SECTION:

TECHNICAL APPROVAL:

APPROVED BY:

APPROVED BY:

APPROVED BY:

REVISIONS

DATE	REV. BY	REVISIONS & ADDED PAGES	REMARKS

GRUMMAN AEROSPACE CORPORATION

GRUMMAN AEROSPACE CORPORATION
BETHPAGE, NEW YORK 11714

TABLE OF CONTENTS

1. INTRODUCTION

The Space Vehicle System Segment (SVSS) of the Earth Observatory Satellite (EOS) System comprises the following

- The Earth Observatory Spacecraft
- The Earth Observatory Spacecraft's Aerospace Ground Equipment
- The Earth Observatory Sensor Payload
- The Earth Observatory Sensor Payload's Aerospace Ground Equipment

The last two elements are supplied to Grumman Aerospace Corporation (GAC) as government furnished equipment by the Associate Contractor (AC).

SVSS integration will be achieved by assuring compatibility of the above listed SVSS elements. This requires that the interfaces between these elements be adequately defined and strictly controlled. To accomplish the latter objectives efficiently it is also necessary that the responsibilities of all involved parties be clearly understood.

This document delineates the program for ensuring proper preparation, review, approval, distribution, and subsequent revisions to SVSS interface control documentation. It also establishes procedures for defining, recording, and implementing the responsibilities of GAC, AC, and all participating NASA agencies, and the procedures and controls which will be used in fulfilling these responsibilities.

2. SCOPE

This plan is applicable only to integration within the SVSS (that is, integration of the above listed elements of the SVSS). In addition to serving as integrator for the SVSS, GAC will support the integration of the SVSS with other segments of the EOS System. However, these activities are not described herein.

3. INTERFACE DOCUMENTATION

3.1 Interface Control Document

The principal piece of integrating documentation for the SVSS will be the Interface Control Document (ICD) between GAC and AC. This document (EOS-113-IC-001) will be developed to define the interfaces with the payload elements of the SVSS. The principal interface characteristics to be described are listed below. Further description of the ICD's contents appears in Section 5.1.

- Spacecraft Configuration
- Spacecraft Operation
- Sensor Physical Characteristics
- Sensor Environments
- Mechanical Interfaces
- Electrical/Electronic Interfaces
- Thermal Interfaces
- Spacecraft AGE/Sensor AGE Interfaces
  - Test Facilities
  - Launch Site

GAC will be the custodian of the ICD and will be responsible for its preparation, maintenance and distribution.

3.2 Interface Revision Notices

Interface Revision Notices (IRN's) will be used to change, add or delete data of specific paragraphs of the approved ICD. IRN's allow timely and expeditious agreements to occur prior to the ICD revisions. They are as formal and binding as the ICD.

IRN's may be initiated by any of the organizations participating in the SVSS design, but will be distributed by GAC. GAC will also be responsible for periodic incorporation of approved IRN's into scheduled revisions of the ICD (see Section 6). Figure 4 of this document will be used by all participating organizations.

3.3 ICD/IRN Approval

Interface agreement will be negotiated between GAC and AC at the technical level. Design changes found to be technically acceptable and which do not affect the respective contracts, will be implemented. Design changes which are technically acceptable, but which do affect one or both contracts, will not be implemented until NASA contractual approval is obtained. When agreement cannot be reached between contractors, NASA direction will be required for disposition of the problem.

ICD and IRN approval will require the signatures of persons authorized to represent NASA, GAC and AC. The persons so authorized are listed below.

3.4 Supporting Interface Documentation

Prior to issuance of the ICD or IRN's, exchanges of other forms of interface documentation (meeting minutes, letters, telefaxes, drawings and sketches, etc.) will be necessary to assure progress of the SVSS design. While these working documents are presented in good faith, they will not represent firm interface commitments.

4. INTERFACE PROCEDURES

4.1 Points of Contact

To maintain orderliness in interface activities and permit accurate visibility of interface status, all interface status, all interface communications are to be made through, or with the knowledge of, single points of contact in each organization. These points of contact are listed below.

4.2 Communications

The following methods of communication will be used for the exchange of interface information.

4.2.1 Telephone

Telephone communications will be made at the discretion of the single point contact in the initiating organization. Data discussed or understandings reached will be described by a follow-up hard copy within one working day. Issuance of the hard copy will be the responsibility of the organization initiating the telephone call.

4.2.2 Telefax

Telefax will be the preferred method of hard copy transmittal and will be used for all correspondence unless impractical for the type of documentation involved. To facilitate future reference, each telefax will be given an identifying number. In addition the telefax will carry the signature of the single point contact.

4.2.3 Letter

Letter correspondence will be used when the type of document precludes the use of telefax. Each organization will use its existing numbering system for identifying letters. Letters will be signed by individuals listed in Para. 3.3 or 4.1

4.2.4 Response to Communications

Whenever a transmittal of interface information occurs, the recipient becomes responsible for determining the adequacy of the information received and/or its effect upon his portion of the EOS system. Unless

and until a response is made by the recipient, the sender will continue working on the assumption that the transmitted information is acceptable to the recipient.

4.3 Meetings

Interface meetings will be held to exchange technical data, review interface status, approve interface documentation and to resolve interface problems or initiate actions leading to their resolution.

4.3.1 Meeting Management

Interface meeting dates, locations and agendas will be defined at least three working days before the meeting is held. The organization initiating the meeting will be responsible for coordinating the above. Meetings will be chaired by the single point contact (Paragraph 4.1) of the host organization or his representative.

4.3.2 Meeting Minutes

Formal minutes will be prepared for each interface meeting; these minutes will include:

- List of attendees
- Summary of the item discussed, including identification of problem areas
- List of documents exchanged
- List of action items assigned (see Paragraph 4.4)
- Status review of interface action items due as of the meeting date.

The host organization will be responsible for preparation of the minutes and distribution of them to the single point contacts listed in Paragraph 4.1. These persons, in turn, will be responsible for distribution of the minutes within their respective organizations. To permit future reference, minutes will be identified, using the host organization's internal document numbering system.

It is desirable that the minutes be prepared and signed by all attending single point contacts prior to their departure. When this is not practicable, it will be necessary that:

- Each organization receives a legible copy of the list of assigned action items, signed as above.
- The formal minutes be prepared and distributed as Spacecraft CDRL Item.

4.4 Action Items

Action items agreed to in interface meetings will represent a commitment by the organization to which they are assigned to perform the action described. These action items will be listed in the meeting minutes; the listing will include:

- Identifying action item number
- Description of the required action
- Identification of the organization responsible for performing the action
- Identification of the recipient organization(s)

4.4.1 Action Item Identification

Action Item numbering will contain the date of the meeting (i.e., Month. Day.Year) and a sequence number assigned to each Action Item as it occurs. If splinter group meetings are convened, the Action Items will be assigned sequence numbers as though a part of the main meeting. The sequence numbers of each meeting will begin at 1. If more than one main meeting occurs in the EOS program on the same day, each meeting will be assigned a Roman Numeral which will precede the sequence number.

Examples: "11.5.73-2" is the 2nd action item from the meeting held on November 5, 1973.

"11.16.73-II-10" is the 10th action item from meeting number two of the meeting held on November 16, 1973.

4.4.2 Action Item Closeouts

Action items will be answered by transmittal of the required interface information on or before the assigned due date using the methods described in Paragraph 4.2 If the assigned due date cannot be met, the organization to which the action was assigned will be responsible for so notifying the intended recipient, negotiating a new due date and informing all other SVSS organizations of the new date. In the event that the transmitted information is inadequate, it is the receiving organization's responsibility to so notify the sender as soon as possible to permit receipt of an adequate response before completion of the action is due.

Formal closeout of action items will be accomplished at interface meetings during the review of action items due and so recorded in the meeting minutes. Only the recipient organization(s) can declare an action item closed.

5. ICD/IRN DESCRIPTION

5.1 ICD/IRN Content

The type and depth of information necessary for adequate interface definition will vary with the individual interface characteristic being described. However, the following paragraphs illustrate the nature of the information which the ICD and the IRN's will contain.

5.1.1 Mechanical Interfaces

Mechanical interfaces will be primarily described by means of drawings which will provide sufficient detail of both sides of the interface to assure:

- Correct dimensional mating with regard to hole patterns and sizes, attachment hardware, etc.
- Material and surface finish compatibility
- Adequate clearances for installation procedures and handling equipment, and for anticipated deflections on both sides of the interface

5.1.2 Electrical Interfaces

Electrical interfaces will be described by text, tabular data and drawings. Schematic drawings will be used to define:

- Functions of each wire
- Pin designations at connectors
- Wire types and sizes

Pictorial drawings will define such characteristics as connector keying orientations and locations.

5.1.3 Fluid Interfaces

Text, tables and curves will be used to describe such characteristics as fluid type, pressure levels, flow rates, fluid temperatures and pressure drops. Pictorial drawings will be used to describe connector locations and types.

5.1.4 Environmental Interfaces

Environmental interface conditions described will include:

- Structural loadings
- Acoustic, vibration and shock levels
- Temperature, pressure and humidity
- Cleanliness

These characteristics will be specified for both ground and flight where different. Text, tables, engineering sketches, and curves will constitute the descriptive material.

5.1.5 Operational Interfaces

Operational interfaces will include descriptions and assignment of responsibility for generating and conducting procedures for handling, cleaning, hoisting, mating, etc., of segments, AVE, and GSE.

5.1.6 Change Impact and Assessment

Each contractor will submit a change impact and assessment directly to NASA for all IRN's. This will be a concise description of the changes to the established configuration baseline which are required to implement the IRN, including schedule changes or other adjustments required, if any.

5.2 <u>ICD/IRN Format</u>

The ICD will carry standard cover sheet on which will appear the ICD number and title, approving signatures and latest revision letter. The ICD will also contain a revision sheet which will indicate the IRN's incorporated in each ICD revision and the authorizing signatures.

IRN's will use a standard cover sheet. This sheet will contain the number, title and revision letter of the ICD against which the IRN is written, as well as the IRN identification number and approval signatures. If the requested revision can be adequately described in the space available, the IRN will consist solely of this cover sheet.

The body of the ICD (and IRN's as necessary) will consist of data sheets. Wherever possible, these "A-size" (8 1/2 x 11 inch) sheets will be used to carry drawings as well as text, tables and curves. Data which are incompatible with presentation on A-size data sheets will use one of the following size sheets:

SHEET SIZE	DIMENSIONS
B	11.0 x 17.0
D	22.0 x 34.0
E	34.0 x 44.0
F	28.0 x 40.0
R	36.0 x up to 120.0

When these larger sizes are used, however, the same information will be carried.

The ICD and IRN's will be prepared on vellum in a manner which will permit a reduction in size suitable for placement in an 8.5 x 11 inch folder. Lettering on the original vellum will be of such a size that when reduced it will be a minimum of 0.08 inch in height. Distribution will be in accordance with the requirements of the Contract, with an added distribution to AC (three regular copies and one reproducible copy of pages larger than A size).

- Milestone 5, the third revision of the ICD, is scheduled to provide an update of interface definition occurring simultaneously with delivery of the sensor payload for installation in the first flight spacecraft.
- Milestone 6, the fourth revision of the ICD, is scheduled to support the Flight Readiness Meeting for the first launch.
- Milestone 7, the final revision of the ICD, will incorporate any IRN's resulting from analysis of the first mission, and will support the Flight Readiness Meeting for the second launch.

6. SCHEDULE OF TASKS

Figure 6 shows the principal tasks and milestones necessary in integrating the SVSS. Adherence to this schedule is required to satisfy the EOS Program Master Schedule.

- Milestone 1, issuance of a preliminary version of the ICD is necessary to provide contractually binding definition of the interface agreements reached as of that date, as well as to focus attention on interface areas requiring further definition prior to the spacecraft Configuration Item Design Review. In the latter regard, the mechanical and environmental interfaces are of particular importance since the release of spacecraft structural drawings will begin immediately after the review.
- Milestone 2, publication of a complete (no "TBD!s"), signed-off ICD is required to support the release of drawings for the Power Distribution Unit and the electrical cabling interfacing with the payload sensor, and the procurement activities associated with the cryogen flow control.
- Milestone 3, the first revision of the ICD, will incorporate all IRN's issued subsequent to Milestone 2. This issue of the ICD will constitute one portion of the SVSS baseline design which will be submitted for approval at the Critical Design Review.
- Milestone 4, second revision of the ICE, will incorporate all IRN's issued subsequent to the Critical Design Review. This revision is scheduled to coincide with the delivery of the flight configuration sensor payload which will be installed in the qualification model spacecraft for demonstration of flight vehicle functional, environmental and EMC performance.

APPENDIX D

APPENDIX D

GRUMMAN AEROSPACE CORPORATION
BETHPAGE, NEW YORK 11714

Date:

MEMORANDUM OF UNDERSTANDING

Grumman Aerospace Corporation and (Instrument Manufacturer)
(Grumman)

Objective

1) Grumman and ____________ wish to offer the ASA a cohesive management plan for a working interface between the ____________ and the proposed EARTH OBSERVATORY SATELLITE (EOS) system.

Ground Rules

2) The anticipated ground rules for such a management plan are:

a. The NASA will contract separately for the development and production of the EOS and the INSTRUMENT.

b. Grumman/Manufacturer will offer the NASA single-point management responsibility through a System Integration Board (SIB) which is chaired by the Grumman management representative and co-chaired by the (Manufacturer) management representative. Additional Grumman and (Manufacturer) specialists may from time-to-time be called on to assist the SIB.

c. Grumman will be responsible for coordinating specifications and acceptance criteria for the EOS with all of its associated subsystems, including the INSTRUMENT. (Manufacturer) is responsible for providing data within the scope and price of its contract with the NASA for use by Grumman in meeting this requirement.

d. Any data supplied by (Manufacturer) to Grumman in response to item 2c above will be subject to coordination with Grumman and approval by the NASA. Any data items which are submitted to Grumman and which are inadequate for its purpose shall be referred to the SIB for disposition in accordance with its charter stated below.

e. Grumman and (Manufacturer) will submit change proposals to the NASA in accordance with their respective contracts. In addition, recommendations on any technical proposal (less cost information) within the purview of the SIB will be furnished to the NASA by the SIB. Such recommendations may be an agreed Grumman/(Manufacturer) position or conflicting separate positions by (Manufacturer) and Grumman. The technical positions forwarded by the SIB will be identical to that contained in the proposals submitted to the NASA by Grumman and/or (Manufacturer).

MEMORANDUM OF UNDERSTANDING	SHEET 1 OF 4	ICD NO.	REV.

GRUMMAN AEROSPACE CORPORATION
BETHPAGE, NEW YORK 11714

Memorandum of Understanding - Grumman and (Manufacturer).

Scope of System/Subsystem Definition

3) a. The INSTRUMENT and the other items to be supplied by (Manufacturer) will be as defined in the terms of its contract with the NASA, through such documents as master indices, system specifications, interface documents, SSE requirements, software definition and acceptance criteria.

b. INSTRUMENT acceptance criteria will be as defined in its contract with the NASA, and these criteria will be made available to Grumman.

c. Grumman will define the EOS system including the EOS/INSTRUMENT interface, the INSTRUMENT and the other system/subsystem interfaces in the system through such documents as master indices, system specifications, interface documents, SSE requirements, software definition, etc.

d. Grumman will define the acceptance criteria for EOS system buy-off. These acceptance criteria will be compatible with the INSTRUMENT data and specifications of item 3v above, including but not limited to configuration and software data and test criteria. Any data items which are submitted to Grumman and which are considered by Grumman to be inadequate for its purposes will be referred to the SIB for disposition.

Charter for SIB

4) a. The SIB is a standing technical/management body whose objectives are as follows:

1. Coordinate the overall weapon system development with respect to Grumman (Manufacturer) interface so that NASA requirements are met in a timely and economic manner.

2. Develop and maintain an Interface Control Record (ICR).

3. Review any proposed changes to the overall system or its subsystems submitted by either NASA, Grumman or (Manufacturer) which wil affect the other contractor in either system performance, schedule or interface control documents.

4. Make recommendations to NASA for disposition of any proposed changes. Recommendations will be forwarded to NASA concurrent with (Manufacturer)/Grumman proposals for implementation of such changes.

5. Monitor the execution of changes and update interface documents accordingly.

MEMORANDUM OF UNDERSTANDING	SHEET 2 OF 4	ICD NO.	REV.

Memorandum of Understanding - Grumman and (Manufacturer)

6. Identify disagreement between (Manufacturer) and Grumman under 4.2.3 above and refer these to the NASA for resolution. It is understood that any disagreement between (Manufacturer) and Grumman arising out of matters other than those under 4.2.3 above may be identified by the SIB and referred to the NASA for resolution if agreed by both parties.

b. The composition of the SIB is as follows:

Chariman: Grumman EOS Program Manager's designee
Associate Chairman: (Manufacturer's) Program Manager's designee
Additional members from Grumman and (Manufacturer) as may be required from time-to-time and mutually agreed by the Chairman and Associate Chairman.

c. The opertaions of the SIB, frequency of meetings and operating procedures shall be established by the SIB. Costs in connection with operation of the SIB will be borne by (Manufacturer) and Grumman as part of and in support of their respective contracts.

d. In the event that the SIB cannot agree upon a single recommendation to be given to NASA or upon any other matter, the Chairman will inform the NASA EOS Program Manager to this effect, and forward the separate positions taken by Grumman and (Manufacturer) for disposition.

e. The SIB will be notified by either Grumman or (Manufacturer) in the event that technical, management or schedule data requested from the other organization is not available through normal channels.

f. In the event that (Manufacturer) or Grumman submits to the SIB or to each other any data considered by them to be proprietary, and such data is so marked, both (Manufacturer) and Grumman will hold such data in confidence with at least the same care and safeguards as are applied to the party's own proprietary information. The receiving party shall not be limited in its use of such information marked as proprietary information as the receiving party rightfully obtains from a third party, already rightfully had in its possession, independently generates, or is in the public domain. The restrictions and obligations herein agreed with respect to proprietary information shall expire three years after receipt by the receiving party or when the delivery party consents in writing, whichever is earlier.

Interface Control

5) Interface control will be achieved through implementation of three jointly agreed-to interface control documents -- the Interface Control Record (ICR) the Agreement of Responsibilities, the EOS/ INSTRUMENT Performance and Integration (P&I) document, for EOS System. It is the intent of

Memorandum of Understanding - Grumman and (Manufacturer)

Grumman and (Manufacturer) that the Agreement of Responsibilities, the EOS/INSTRUMENT Performance and Integration Document, and this Memorandum of Agreement be included in contracts between (Manufacturer) and the NASA and Grumman and the NASA.

Termination

6) This agreement will terminate (except with respect to safeguarding proprietary information) upon the earliest of the following:

a. Grumman and (Manufacturer) mutually agree to terminate it.

b. (Manfacturer) is not awarded a prime contract for furnishing the INSTRUMENT for inclusion in the EOS.

c. Grumman is not awarded a prime contract for the EOS system.

d. In the event that this agreement is not consistent with the respective contracts between Grumman and the Navy and (Manufacturer) and the parties hereto fail to modify this agreement to their mutual satisfaction.

e. The incorporation into the contracts between (Manufacturer) and the NSAS and Grumman and the NASA of the Agreement of Responsibilities,
The EOS/INSTRUMENT Performance and Integration Document and this Memorandum of Agreement referred to in Paragraph 5 (Interface Control).

APPENDIX E

APPENDIX E

REV. "A"

AGREEMENT OF RESPONSIBILITIES

BETWEEN GRUMMAN AND (ASSOCIATE)

27 JUNE 1974

GRUMMAN AEROSPACE CORPORATION ______________________________

ASSOCIATE ______________________________

GRUMMAN AEROSPACE CORPORATION
BETHPAGE, NEW YORK 11714

CONTENTS

ARTICLE I - OBJECTIVE

This agreement between Grumman and (Associate) establishes a Joint Liaison Plan to achieve compatibility between the Earth Observatory System and the payload instrument such that the timely and economical development of an operational system will result.

The Plan defines each contractors interface responsibilities, the organization and procedures for communication and control, and prescribes schedules for accomplishment of requirements with the intent of avoiding procedural delays by development of a flexible and effective working relationship.

This agreement between Grumman and Associate will become a part of each contractors individual Prime Contract with the Government. After Prime Contract execution, any change to this agreement will require corresponding Prime Contract Changes.

Reference is made to the Memorandum of Agreement between Grumman Aircraft Engineering Corporation and Associate initiating a working interface for preparation of this agreement. (Exhibit B)

ARTICLE II - DEFINITIONS

For the purpose of this Agreement, the following terms shall have the meanings set forth below:

The following definitions are included herein for reference only. The definition contained in item c above shall take precedence.

ARTICLE III - EXHIBITS

The following Exhibits attached hereto are hereby incorporated herein and made a part hereof:

Exhibit A - Performance and Interface Document dated .

Exhibit B - Memorandum of Agreement dated . Each Party shall be responsible for meeting its requirements set forth in the above Exhibits.

Exhibit C - SIB Operational Procedures. This document is included for reference only and is not to be considered a part of the understanding of responsibilities for contractual purposes.

ARTICLE IV - GENERAL RESPONSIBILITIES

Grumman is responsible for contracting for the Earth Observatory System Specification with the Government and is directly responsible to the Government for meeting those specification requirements in accordance with the terms of its prime contract. This responsibility includes meeting the provisions of this agreement and the Performance and Interface Document.

Associate is directly responsible to the Government for meeting the Instrument specification requirements in accordance with the terms of its prime contract. This responsibility includes meeting the provisions of this agreement and the Performance and Interface Document.

Grumman is responsible for overall system performance.

ARTICLE V - PROGRAM COORDINATION AND CONTROL

1. General

a. Grumman and Associate shall provide, within their program organizations, a coordination and control point which shall function over the period from initial design through the Logistic Support Period, including system integration and production.

b. ICD Coordinators
Each contractor shall appoint a System Coordinator to perform continuous liaison with his counterpart for the purpose of processing and expediting ICD interface matters e.g., integration of equipment, and technical data, configuration management, and training. Documentation relating to interface matters, shall be transmitted between contractors as soon as available and comments or approvals when required shall be processed within 10 working days of receipt of such material. See Figure 1 1 and 2

c. Engineering Coordination
Each contractor shall make every effort to resolve problem areas by routine exchange of correspondence or direct liaison between respective engineering groups. When differences of opinion develop which cannot be resolved routinely, such differences shall be submitted to the System Integration Board for resolution. See Figure 1 3.

2. System Integration Board (SIB)

Reference is made to Exhibit B of this document. Grumman and Associate shall jointly establish a System Integration Board to provide for the coordinated review of the weapon system development with respect to the interface. Consistent with this purpose, all interface matters shall be brought to the attention of the SIB. See Figure 1 3 4 5

b. The SIB, through its Chairman, will keep the Government informed of overall System integration and development progress. See Figure 1 8

The System Integration Board shall be composed of permanent representatives from each party. One permanent member appointed by each contractor shall be the Configuration Manager of his designee.

The System Integration Board shall request the attendance of a NASA representative when it appears that advance notification or detailed knowledge of the SIB's agenda item(s) will assist NASA in rendering a decision.

The Chairman shall be designated by Grumman and Associate Chairman, designated by Associate. Additional personnel may assist the SIB as the Chairman or Associate Chairman may deem necessary to most effectively contribute to the meeting agenda. The Chairman or Associate Chairman shall call the SIB into session at such locations as may be relevant in order:

(1) to provide for detailed investigation of special problems by appropriate personnel of each organization, to resolve any disagreement and to implement decisions.

(2) to maintain a high level of awareness concerning the overall program status among responsible program personnel by providing a favorable climate for the direct and uninhibited interchange of information and data of mutual concern.

(3) to provide the informational basis for periodic program coordination status reporting to the EOS NASA Program office.

The duties of the SIB shall consist of:

A. Design Integration

The SIB shall continuously review and monitor design integration efforts (including software, development and integration) as regards accomplishment of the task set forth in the P&I Document and Article X, and shall periodically report to the Government the status of these efforts with respect to the task arrangements and schedules.

B. Support

The SIB shall perform Facilities Support, Test Support, and Logistic Support Coordination in accordance with Article X.

C. Schedule Management

The SIB shall coordinate, monitor and report to the NASA EOS program manager the contractors' schedules for their integration and production programs in accordance with the Article X.

D. Data Exchange

The SIB shall facilitate data exchange between the contractors including but not limited to the data included in Article IX.

E. Operating Procedures

The operating procedures agreed upon by the contractors shall be followed for the SIB operations, recording of the proceedings of Design/Program meetings, communications, data exchange requirements and Interface Control Record preparation. Changes to these procedures shall require mutual agreement of the contractors. These procedures which are not a part of the prime contracts, shall be bound separately from any contract document.

F. Interface Control Document

Grumman will originate and maintain the Interface Control Document (ICD), for the EOS system. The ICD contains the detail hardware interface parameters as mutually defined during the design integration period. The ICD shall include, but not be limited to, data covering the following areas:

(1) Electrical
(2) Mechanical
(3) Environmental
(4) Installation
(5) Instrumentation

The ICD shall be prepared to record the physical characteristics, electrical characteristics and requirements of the PMS/Airframe Interface. Provisions will be included for recording major changes between successive issues of the document such as required by approved E.C.P.'s. Since the ICD is a mutual agreement between Grumman and Associate, mutual agreement between the contractors is required to change the ICD.

G. Change Management

The SIB shall supervise change management in accordance with Article VI.

H. Interface Problems

The SIB shall identify and resolve interface problems arising during the development in accordance with Article VII.

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ARTICLE VI - CHANGES

During Contract Definition a baseline configuration has been defined by the EOS Detail Specification, Instrument Detail Specification, and P&I Document. In addition, the ICD shall provide a baseline record during development. Changes to the baseline configuration shall be accomplsihed in accordance with the following paragraphs.

Neither party shall make changes affecting the interface without prior coordination with the other. Both parties may make any design changes without the approval of the other party provided such changes do not affect the interface. Any change in the P&I Document must have the agreement of both parties and the approval of the Government. Changes to the ICD require the agreement of both parties, but not the Government until Product Configuration Audit (PCA). After Product Configuration Audit (PCA, the only changes permitted in the Interface Control Document will be the agreed upon changes required to implement NASA approved Engineering Change Proposals ECPS).

Each party shall secure the agreement of the other for any specification change which affects the interface. Each party shall keep the SIB advised of any action to be taken with the Government regarding unresolved specification differences. See Figure 1 4 5

The SIB shall review all Interface Changes, as submitted by either the Government, Grumman or Associate to either contractor transmitting the change to the Government. If the change does not require Government approval and is approved by the Board, it shall be returned directly to the contractors for implementation.

If the change requires Government Approval, the SIB shall coordinate contractors efforts to reach mutually agreed upon technical proposals. The SIB shall render a decision on all changes referred to it pursuant to this Section within ten (10) working days of receipt of the proposed change. The SIB shall forward its recommendation with the agreed upon technical proposals to the Navy SA EOS. Program Manager. See Figure 8 Concurrently Grumman and Associate shall forward their same technical proposals and the firm costs associated therewith, if any, to the respective contracting officers.

In the event that the SIB cannot agree upon a single recommendation to be given the Government, or in the event of a failure to make a decision within ten (10) working days or an agreed upon extension, the Chairman will inform the NA SA EOS Grumman and Associate for disposition. In this same event, Grumman and Associate shall each at that time submit the proposed change with the firm cost effect, if any, to their respective contracting officers.

When agreed to and approved, the implementation/incorporation of all EOS System changes shall be coordinated through the SIB.

ARTICLE VII - FULFILLMENT OF EOS SYSTEM RESPONSIBILITIES

For the purposes of this article, the word "problem" is used to include the meaning defect or deficiency as applicable when so defined by the Contracting Officers.

1. Identification and Investigation of EOS System Problems

In the event it is determined by either party or asserted by the Government that the system does not, or it appears to one of the parties that it will not fulfill EOS system performance requirements, which requirements are specified in Grumman's prime contract with the Government, and the problem is or could be materially related to the Instrument as it forms a part of the system, then the party with knowledge of the actual or potential problem shall promptly notify the SIB through the Instrument system coordinator in writing of such determination or assertion. SIB shall immediately schedule a meeting at which the party determining the existence or potential existence of the problem shall make available all the information in its possession which relates thereto as it affects the other party. SIB shall then work to investigate the cause of the problem and to determine the most practical correction. Thereafter, the SIB shall periodically meet to review progress, exchange information developed in the course of the investigation and agree upon any additional investigation plans.

2. Correction of Defects (Problems)

A. Agreement

Upon completion of the investigation, the SIB shall meet and each party shall candidly disclose and furnish to the other its available technical data pertinent to the problem, its tentative engineering analysis thereof, and descriptions of the possible corrective action(s) it can perform. If the SIB agrees on the corrective action and the action falls within the scope/responsibility of the parties' respective prime contracts with the Government, each party shall immediately proceed to implement its agreed upon action following any necessary Government approval.

B. Disagreement

In case agreement is not reached within ten working days or an agreed upon extension of the presentation of the problem to the SIB, each party shall then document its position to the SIB. The respective statements of position will be combined into a single document for presentation by the SIB to the NASA EOS Project Manager and Contracting Officers for decision.

The NASA's decision, as provided for in the contractors' respective prime contracts, shall be final and conclusive except in the event of a dispute as defined under the applicable Prime Contract. In the event of a dispute, the procedures of appeal shall be pursued. However, nothing

in this Article shall excuse either party from proceeding with performance of this agreement pursuant to the NASA's decision.

All of the above shall be done in accordance with SIB operating procedure.

Grumman's responsibility for retrofit under this article is defined by its prime contract with the Government.

3. Compensating Corrections

In the event the EOS System does not fulfill EOS System Performance (system deficiency), or the Instrument does not fulfill requirements as defined in Associate prime contract (Instrument deficiency), and such deficiency can reasonably be corrected or compensated for by improved performance of the Instrument or the space frame, respectively, beyond prime contract requirements, such improved performance may be offered to the other party. Upon approval of the SIB, appropriate changes shall be processed in accordance with Article VI changes. Upon receipt of contractual authority to proceed, each party agrees to commence such correction or compensating action in accordance with its proposal.

4. Non-Defect

For action outside the scope/responsibility of the parties' respective prime contracts, appropriate changes shall be processed in accordance with Article VI - Changes.

The NASA contracting officer's written decision shall be final and conclusive except in the event of a dispute as defined under the applicable Prime Contract. In the event of a dispute, the procedures of appeal shall be pursued. However, nothing in this Article shall excuse either party from proceeding with performance of this agreement pursuant to the NASA decision.

All of the above shall be done in accordance with SIB operating procedure (Exhibit C).

ARTICLE VIII - DATA

The parties shall exchange such technical information and data as is required for each to perform its obligations hereunder. Each party agrees that any information or data delivered to it by the other party which is marked "Proprietary" and is not in the public domain or otherwise available shall, except as authorized by the other party, be handled and preserved with the same degree of care which the receiving party affords its own proprietary data, provided, however, that neither party shall be liable for inadvertent disclosure of any proprietary data.

ARTICLE IX - DATA EXCHANGE

Data shall be exchanged between Grumman and Associate including, but not limited to, the following data. The SIB shall resolve disagreements regarding data exchange.

A. Drawings and Associated Data

Associate to Grumman

1. Layout drawings of equipment
2. Layout drawings of Instrument/Data Management System interface

Grumman to Associate

1. Layout drawings of compartments
2. Outline drawings (in-board profiles, etc.)

B. Engineering Data

Associate to Grumman

1. Subsystem and system parameters and tolerances
2. System engineering analysis reports and updating changes
3. Specifications of equipment
4. Functional interface descriptions
5. Electrical interface descriptions
6. Power, cooling, and pressurization requirements substantiated by detailed analysis
7. Mechanical interface requirements
8. Weight and volume (form) data (including depth dimension of the end of the attaching connectors and cable clamps)
9. Equipment/system performance characteristics needed for aircraft analysis
10. Environment requirements substantiated by detailed analysis
11. Existing data, to include, but not limited to:

12. Center of Gravity for each WRA
13. Instrumentation functional interface descriptions
14. Instrumentation electrical interface descriptions
15. Instrumentation mechanical interface descriptions

ARTICLE X - TASKS AND SCHEDULES

This article defines the integration program and associated tasks which shall be accomplished by Grumman and Hughes, including schedules (Attachment 1) for the accomplishment of the tasks. The schedules of Attachment 1 will be updated to show the major milestones which are contractual between Grumman and NASA and between Associate and NASA. All other schedule events are for planning purposes and may be changed by mutual agreement between Grumman and Associate. The SIB shall resolve disagreements regarding tasks and schedules. This article is divided into four sections:

ARTICLE XI - LIAISON/FACILITIES

A. Liaison

Each party will make suitable arrangements for assignment of its technical or other personnel in the plant of the other, as required, in order to facilitate successful interface. Each party will make available suitable office space, and reasonable related services and equipment for a mutually agreed upon number of personnel of the other party during assignment or visits to its plants at no cost to the other. Each party will be responsible for providing transportation, subsistence, housing and all other related costs for its employees who are assigned or visit the plants of the other party. Either party may, on reasonable grounds, request removal of the other party's assigned personnel. The other party will comply with such request but without prejudice to any right to supply replacements. The person or persons so removed will not be reassigned to said facilities unless and until the parties concur in such reassignment.

If it is necessary for either party to have access to the facilities of a subcontractor of the other party, the arrangements for, and the rights and obligations applicable to, such right of access will, if required, and to the extent permitted by the applicable subcontract, be arranged for the requesting party by the other party with the subcontractor to whose facilities the right of access relates.

Each contractor shall be permitted to send technical observers to witness any program contained herein to be performed by its associate contractor.

Liaison personnel shall be subject to the operating procedures established by the SIB.

ARTICLE XII - ENGINEERING/TECHNICAL SUPPORT

The following engineering/technical support shall be provided by the respective contractors.

1. Associate to Grumman

   a. Provide engineering personnel as part of the Grumman test teams.

   b. Associate Resident Representative at Grumman

      1) Personnel management
      2) Liaison

2. Grumman to Associate

   a. Engineering personnel to provide support of EOS Test Bed at Associates.

   b. Grumman Resident Manager at Associate

      1) Personnel Management
      2) Liaison

   c. Engineering Test Team

      1) Test Support and Monitor
      2) Flight Test Representative
      3) Engineering Resident Representative

   d. Special Engineering Support as required by:

      1) Acceptance Test Procedures
      2) Joint Government/Grumman Acceptance Team
      3) Grumman Systems and Equipment Problems

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ARTICLE XIII - COST

Costs incurred by either party in order to implement this agreement and their respective specifications as expanded by the P & I document and approved by the Government will be borne separately by Grumman and Associate under their respective prime contracts.

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ARTICLE XIV - RELATIONSHIP OF PARTIES

It is understood that each party is an independent contractor and that all persons engaged in work under this Agreement who are furnished by either party are employees of the furnishing party and shall in no sense by employees or agents of the other party. It is further agreed that neither party shall have the right to act as the agent or legal representative of the other or to bind the other in any respect whatsoever or to incur any debts or liabilities in the name or on behalf of the other.

Nothing contained in this Agreement shall be construed to require or authorize Grumman or Associate to undertake any action not required and authorized under its prime contract unless appropriate contract adjustments are first made in the prime contract of the party taking the action.

Grumman and Associate agree that neither should be held liable for any failure on the part of the other to meet its contractual requirements with the Government.

ARTICLE XV - DURATION OF AGREEMENT

This Agreement shall become effective upon the last to occur of the date of award to Grumman and Associate of prime contracts with the Government for the EOS System development and the instrument development, respectively, and shall continue in full force and effect so long as both parties hold such contracts.

This Agreement and the Exhibits referenced herein may be amended from time to time by the mutual agreement of the parties subject to any necessary approval of the Government.

Upon execution and upon any subsequent modification of prime contracts between each of the parties and the Government, the parties shall enter into negotiations to amend this Agreement and the Exhibits thereto, as appropriate, to recognize the terms of the instrument contract and the EOS contract.